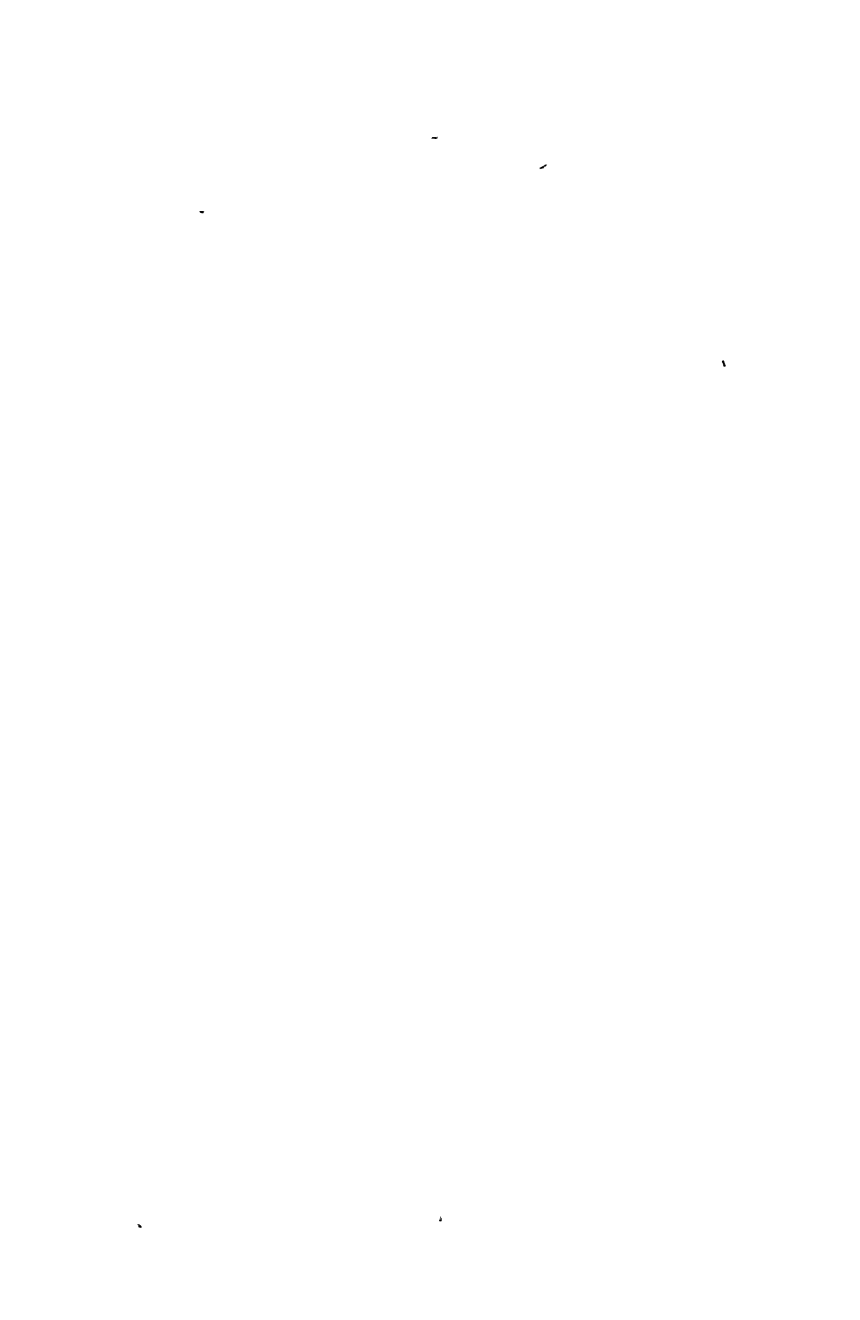


THE PREPARATION OF ENGINEERING REPORTS

*The quality of the materials used in the manufacture
of this book is governed by continued postwar shortages.*



THE PREPARATION OF ENGINEERING REPORTS

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PREFACE

This book was written to serve as the basis for a brief course dealing with the content and form of engineering reports. The course had the twofold purpose of providing a means of reviewing the English performance of engineering students subsequent to the completion of the formal courses in English and of giving training in the orderly presentation of subject matter in the form of engineering reports. Engineers in professional practice who write occasional reports will find this book to be convenient for reference, particularly those parts that deal with the formal report and the sections that discuss punctuation, abbreviations, and style, as these are matters upon which the engineer who does not frequently write reports may sometimes find himself at loss.

The intention was to prepare a manual that would serve as a guide in the actual writing of engineering reports and therefore be most useful in a course requiring the student to do a good deal of writing on engineering subjects. However, in order to have something definite to write about, it is incumbent upon the student to obtain information on a subject. Therefore the notes include suggestions on obtaining and organizing the subject matter preparatory to writing the report.

It is to be regretted that Prof. W. L. Foster, who had collaborated in the preparation of the manu-

script, met an untimely death before the work was completed. He had devoted considerable time to the work and had for several years taught report writing to classes of engineering students. Subsequently, Prof. Frank Kerekes of the Civil Engineering Department at Iowa State College took over some of the classes in this subject and as a result of his experience in teaching has made valuable suggestions. Also Prof. W. Paul Jones of the Department of English at Iowa State College reviewed the manuscript and made helpful comments.

THOMAS R. AGG.

AMES, IOWA,
April, 1935.

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CHAPTER I

THE ENGINEERING REPORT

The engineering report is a form of technical writing employed for transmitting engineering information and its distinctive characteristics have gradually evolved out of the experience of those engineers who have had occasion to write reports and have sought an effective form in which to present the results of their study of some engineering problem.

The engineering report is, in essence, the answer to a question on some engineering subject. The verbal or written answer to a casual question about some everyday matter may well be the briefest statement that will serve the purpose. Answering an engineering question of any moment must be regarded as a much more involved matter than the mere statement of what is considered the correct answer. It is, in many cases, desirable to include with the answer to the question a recital of certain facts believed to be fundamental to a solution of the problem, an outline of the basic principles relied upon in the application of the facts to the problem under consideration, and a discussion of the line of reasoning or the analytical process by which the particular conclusion was reached.

The employment of the engineering report in the various phases of engineering practice has become so

widespread that no one can continue very long in engineering work without either writing or receiving an engineering report of some kind. The engineering student will be required to write brief reports early in his formal training and before he has completed his undergraduate training will have written many reports, some of which were rather pretentious. He will doubtless write reports from time to time throughout his professional career and may hope that some of these will be worthy contributions to engineering literature.

Engineering reports tend to conform to a common pattern with respect to style and arrangement. This pattern accommodates itself to the practice of presenting the subject matter of the report according to a plan that seems to promote clearness, to facilitate examination, and to carry conviction. Probably the influence of the mathematical training of the engineer is in part responsible for the adoption of a form of presentation for reports that seems to be akin to that employed in formal geometry. Engineers are familiar with the method in which a proposition is stated, certain figures are constructed and their correctness proved, then a conclusion drawn which is the solution of the original proposition. In engineering reports the reader is led from the question, through an array of facts, theories, and arguments, to a conclusion which is the answer to the question. Throughout, the attempt is made to lead the reader steadily along through a mass of evidence that leads logically to the stated conclusion.

Not all engineering reports are prepared to answer a specific question that has been propounded for the express purpose of securing a report. Many reports

are of that type, of course, but other types will also be encountered. There are many questions about engineering subjects that have been discussed in professional meetings and by the technical press without a conclusive answer having been forthcoming. Reports often deal with subjects of this type, the purpose being to give to the profession some additional facts that may lead another step toward a solution of the problem. Many research reports and certain of the papers published by the engineering journals and the professional societies are of this type.

Engineers who have handled interesting design or construction projects sometimes report on their work as a means of informing the profession as to the problems encountered and the solutions devised for them. These reports are usually written in narrative form but are sometimes presented in the conventional report form.

The Nature of Engineering Reports

The engineering reports differ from certain kinds of general business reports only in the nature of the subject matter and therefore the discussion that follows may be applicable, in general, to reports on other than engineering subjects. However, it is desired to confine attention herein to those types of reports with which the engineer deals.

Subject Matter.—The subject matter dealt with in engineering reports includes that of the many branches of engineering and a bordering fringe of finance, economics, and industrial management.

The complexity and magnitude of many of the modern engineering enterprises have resulted in the

development of organizations of which units exist in widely separated places, yet these must function under centralized control. The engineering report dealing with the technical phases of the various projects is one instrumentality employed for the management of the widely scattered activities of such organizations.

There are no geographical limitations to the operations of present-day industry, and the activities of many great industries require engineering services at locations far removed from the general offices. Here again the engineering report is one means of control of these far-flung enterprises, but such reports are frequently much more than technical engineering reports. They are likely to include also much material dealing with the economic and management phases of the problems discussed.

Uses of Engineering Reports.—An understanding of the use that is made of the engineering report will serve to indicate the nature of the obligation that rests upon the engineer who prepares a report. A few typical illustrations will be given to indicate the more common uses of engineering reports.

1. In administrative control of engineering work in organizations so large as to preclude frequent contact between administrative officers and the various grades of staff members. This is probably the field in which the engineering report finds the most extensive use.

2. As a feature of the development program of industries that manufacture products requiring engineering design. Here the engineering report is a preliminary to bringing out new products or improved designs for the current products.

3. As a preliminary to the construction of new industrial plants, the modernization of existing plants, or the undertaking of public works of a magnitude greater than that of a routine or standardized character.

4. As a vehicle for the dissemination of new engineering data which are the outgrowth of research or of experience with the design, construction, operation, or management of engineering enterprises.

Reports Include Basic Data.—One characteristic of engineering reports is that they generally include the basic data that were assembled in formulating the report. An executive will seldom assume responsibility for the report of a subordinate until the report has been studied and the conclusions checked. It is customary, therefore, to include in the report all of the data required for a verification of the essential parts of the work. Even in those cases where the engineer knows his recommendations will be accepted without question by his present superior, there is always the possibility that a change in personnel may result in the report being handled by a man who is new to the organization and who will, therefore, wish to be able to ascertain the basis and reliability of the recommendations in the report. Reports are frequently made on projects that are slow to reach the stage of construction and the report may be filed for future reference. When the project again comes up for action it may be handled by an entirely different personnel from that which originally worked on it. The report should be sufficiently comprehensive to permit the new personnel to gain a clear understanding of the whole matter by a study of the report.

Reports Are Answers to Questions.—Engineering reports quite frequently originate in a request for information. When the problem is simple the request may be verbal, although even in such cases it is likely to be written. When relating to the more complex problems of professional practice, the request for information may comprise a number of pages of detailed specifications and limitations. The request for information may be sent from an engineer to a subordinate on his staff or to an engineer of collateral standing in another division of the organization in which both are employed. It may be submitted to a consulting engineer by a client. It may be made by one consulting engineer to another. Sometimes a supervising board or commission will send the request for information to its engineering organization. The request may be a part of the routine of the organization, or it may be the outgrowth of some special situation. In whatever manner it may arise, a request for information—for the answer to a question—is the occasion for the preparation of most engineering reports. There is some specific problem presented for solution, or some definite information requested.

Diversity of View Points Among Report Writers

Personal Factors.—It is wholly possible for two experts to present reports on the same subject in which very different conclusions are reached. That is, the bearing of certain facts upon the problem at hand is often a matter of informed judgment and experts do not always agree upon the significance of the complicated and sometimes apparently inconsistent data that are assembled in the study of engineering prob-

lems. Of course, it should be the aim of the writer to formulate a report on such clear grounds that a consideration of the facts presented will lead inevitably to the conclusions drawn. But facts, like well-cut gems, present many facets and their appearance varies with the surroundings in which they are viewed. Therefore the writer of an engineering report must expect that, quite frequently, his facts will be viewed in various lights and will present one shade of meaning to one reader and a different shade of meaning to another.

Physical Factors.—The physical factors upon which some types of reports are based are not always conclusive evidence. It might happen, for example, that data are included in a report which show conclusively that the compressive strength of the concrete in test specimens taken from the concrete used in a certain piece of construction averaged 1,500 pounds per square inch at an age of 28 days, whereas the design contemplated a strength of 3,000 pounds per square inch and the specifications provided for a mixture to give that strength. The fact that the concrete is not so strong as was intended is inescapable. But when one passes to a discussion of why the concrete is not of the desired strength, many factors must be considered. If the report seeks to place the responsibility for the low strength of the concrete, it must discuss the aggregates, the proportions, the time of mixing, the temperature during the setting period, the consistency, the curing conditions, and perhaps numerous other things. Each fact with reference to these several elements of the problem will have some significance, but rarely would experts

Construction reports may be written to show progress and costs, to justify adopted methods of performing work, or to propose the use of new methods or equipment, or for various other related purposes. Some construction reports are also periodic, being filed at regular intervals as a record of progress and cost. The construction report should not be confused with the descriptive general article detailing the method of carrying on a piece of construction, although, when such an article includes data to substantiate the economy of the methods of procedure and records of the cost of the different elements, it is a true engineering report.

Frequently, engineers are called upon to prepare non-technical reports on the construction of public works to be published for the information of the public. Because the general reader would not understand the greater part of the technical discussions that would ordinarily be included in an engineering report, it is customary to include only the most elementary engineering data in a report of this kind. Ability to write reports of this character that are sufficiently interesting and readable to be used by newspapers and magazines is a great asset to the engineer.

Preliminary reports are frequently desirable when an engineering project is contemplated. Such a report will serve to indicate the conditions under which the work will be carried out and the probable cost. In many instances these reports are a preliminary to financing. Preliminary reports usually provide the answers to several questions, such as: Is the construction feasible? Will it prove possible

to operate at a profit? What will the work cost? What will be the basis of design? Reports of this type are very common and the preparation thereof exceedingly exacting because the financial outcome of the enterprise will be dependent in part upon the correctness of the information thus presented.

Reports preliminary to the development of quarries, mines, oil fields, clay deposits, and similar natural resources are of the same general type as those preliminary to construction, but the economic phases are more strongly emphasized. Many business reports carry, as part of the data, an engineering report on the development phases of the project. In most instances these reports are a preliminary to financing the project.

Reports on design may be intended to afford the data upon which to base the design of a structure; they may propose a design; or they may establish the condition of stability provided for by a design already completed. Usually the designs for important structures and for structures of new types are submitted to consultants to be checked. Reports of this type constitute an important part of the practice of well-established consulting engineers.

Research reports are prepared by a great many agencies, some of which function within an industry or group of industries, while others are maintained by publicly supported institutions. The results of the work of these agencies are presented in reports which are usually published as bulletins or technical papers. While the engineering research report is a true engineering report, it may depart from the customary form in various particulars because

the very circumstance of its incidence in a research organization which is primarily interested in developing new data makes some departure from the standard rather to be expected. In general, however, it will be found that research reports on engineering subjects follow rather closely the accepted form of the engineering report.

Reports on failures of engineering structures, or "post mortems," are in a class by themselves because the conditions under which they arise are scarcely ever alike in any two instances. The method of attack and the form employed for reporting on failures of engineering structures are like those for any other kind of engineering report. It often happens, however, that a conclusive answer to the question of what caused the failure is not possible.

Reports on tests may be routine or special, depending upon the circumstances. Simple tests on individual specimens are presented adequately by brief reports, but exhaustive tests of a special nature may require elaborate reports. Very often, routine tests are reported on prepared forms which are really greatly abridged engineering reports.

Valuation reports present an answer to a question as to the value of a property on some specified basis. Since reports of this type are generally studied by laymen, by lawyers, and sometimes by the courts, the presentation must be complete and convincing and yet so arranged that each type of reader will be able to isolate and comprehend the particular part of the findings in which he is especially interested.

While the foregoing classes of engineering reports are frequently encountered and perhaps include the

more common and widely used kinds, the list is by no means complete. It is intended to be illustrative only and other classes of reports result from miscellaneous requests for engineering data or general information. They differ from the classes mentioned only in subject matter.

Types of Engineering Reports

There are two general types from which to select in presenting the findings of an engineering investigation. Which one of the types will be employed in a specific case will depend upon the complexity of the problem involved and the scope of the supporting material presented.

1. The **informal report** or, as it is sometimes called, the **letter report**, is used to present a short, concise answer to a relatively simple engineering question, in which it is unnecessary to include any considerable amount of supporting data. It is usually written in the first person in the form of a business letter. Its length seldom exceeds about twenty typed pages and frequently consists of no more than three or four.

2. The **formal report** is employed to present the answer to an engineering question requiring the accumulation of considerable data and the analysis of complex and voluminous evidence which must be submitted, at least in substance, in support of the conclusions presented. It is written in the third person.

Since the engineering report appears in so many guises and varies so greatly in length and complexity,

it is important to recognize that all engineering reports have two characteristics in common: (1) They seek to present a solution to an engineering problem or to give specific information on some definite project. (2) They are written in conformity with a literary form that has been evolved in an attempt to promote clearness, definiteness, and convenience to the reader.

The engineering report differs from other forms of technical writing in that, in general, it entails the presentation of *evidence* bearing upon a specific problem as well as a solution to the problem.

Engineering reports range in length from brief letters to books of hundreds of printed pages. The subject matter may relate to some simple test of a machine or it may deal with a project of great magnitude, such as the construction of a high-tension transmission line or a gigantic power station. The report may be (occasionally) in handwriting, it may be typewritten, or it may be printed.

Elements of the Engineering Report

The elements of the engineering report, in the order in which they appear, are: the title page; the preface or foreword, or the letter or letters of transmittal; the table of contents; the abstract (not always introduced); the text or main body of the report; the summary or statement of conclusions; the appendices (not always included); and the index, if the report is long enough to require one.

While some latitude is allowable with reference to the inclusion of all of these elements, and the exact

order in which they appear, the reports that may be considered typical and generally satisfactory to the reader adhere rather closely to the arrangement outlined above. Each of the elements will be discussed in the following pages and the report writer may determine for himself how closely he should conform to the foregoing pattern.

CHAPTER II

INFORMAL ENGINEERING REPORTS

The informal report is the kind the engineer is likely to encounter first in his engineering work and the reports he prepares during the early years of his professional experience will probably be of this type. Generally, this first simple report will be in the nature of a letter he writes in answer to an inquiry about some detail of the work upon which he is engaged and he may not recognize the occasion as one inviting the use of this type of report. Sometimes the inquiry that is the opportunity for an informal report will appear at first to be almost trivial or at most of rather minor importance, and there will perhaps be a temptation to scribble off a haphazard letter that seems to be all the occasion demands. However, if the person who made the inquiry believes it to be of some importance, he will have little patience with a subordinate who, in reply, writes a letter which must be read and reread before its meaning becomes clear or which fails to answer the inquiry adequately. On the contrary, the executive expects, or at least hopes, to secure from the members of his staff clear, concise, and complete replies to inquiries, no matter how simple the question.

It is desirable that the information contained in informal reports be correct and pertinent to the

question or the report is of little value. But even when the technical material submitted is correct, there is a conventional form in which it can be presented that enables the reader to get at the facts quickly and, in addition, facilitates filing and reference to the report at a later time.

The informal report is no more than a business letter in which care has been exercised to submit information in a certain form which is really that of the formal report with the elements abridged or conventionalized, but usually all included in some manner.

Elements of Informal Reports

Title.—Occasionally a title page is used with an informal report, but more frequently the title-page information is given by the letterhead, address, and subject line. The name of the writer and his professional connection or status is indicated by the printed or typed letterhead. The person for whom the report is intended is given by the formal address. The title of the report is indicated in the subject line at the beginning of the letter, a device no longer widely used although once very common. The date of the report is the date of the letter.

These are standard for business letters and yet entirely too often certain of the elements are missing in letter reports. Each element serves a useful purpose and therefore each should be included no matter how familiar the subject or how informal the relations of the persons between whom the letter passes. It is well to remember that the matter about which the letter was written may be deferred and the letter filed. Months later it may come up for action

and an entirely new personnel may be handling the project at that time. It will be a convenience to all concerned if the report is found to be fully identified in every particular.

There is no table of contents in the informal report because its length is such that none is required.

Statement of Problem.—The first paragraph or two of the letter are used to state the problem or question and thus indicate why the report is being written. The statement of the problem or question dealt with in the letter should be carefully worded to insure against the particular report being confused with others of a similar nature. If it is in reply to a specific request, that fact is noted; if it is submitted without request by way of giving information or advice believed to be pertinent to the work at hand, that is stated. In any case the specific question or problem dealt with is clearly defined so as to insure that the nature of the report is indicated and the reason for its being written fully explained.

Summary.—A paragraph or two might well consist of a digest of the conclusion reached or the recommendation offered. This information need not be set forth at length but, if included at this point, will direct the reader's attention to what the report is attempting to bring to attention or to suggest. The reader will have the writer's views in mind as he reads and will be prepared to weigh the various statements that follow to determine whether these support the conclusions set forth in the report. The general idea is to follow a scheme that is much like the formal method of presenting the subject of geometry. The proposition is stated, the things given are enumerated,

the construction and proof follow and the conclusion is reached, which is the original proposition. But each part must follow logically what has preceded.

Body of the Report.—The body of the letter written as an informal report corresponds to the main body of a formal report and contains the facts, theories, and arguments that support the conclusion. This part of the report must be reasonably complete; but since such reports usually deal with relatively simple matters, voluminous evidence is seldom needed.

Conclusion.—The informal report leads to some kind of conclusion, suggestion, request, or opinion, which naturally and logically follows the evidence included in the body of the letter. This conclusion is stated in a single paragraph or two or, at most, in about a page of typed material. The signature follows this paragraph as authentication of the material.

Appendices.—The appendices that might be included in the formal report become enclosures when filed with a letter of the informal report type. They are marked "Exhibit No. 1," "Exhibit No. 2," or "Enclosure No. 1," etc. These enclosures may consist of drawings, laboratory report sheets, letters, or any other kind of document that is pertinent and may be useful in dealing with the question with which the report concerns itself.

Uses of Informal Reports

Interdepartmental Correspondence.—In technical or industrial organizations, informal reports pass between individuals in a continuous stream in the ordinary conduct of the affairs with which they are

engaged, and such reports are not readily differentiated from ordinary business correspondence. The distinguishing characteristic of the informal engineering report is that it involves *answering an inquiry* that generally requires some investigation before a satisfactory reply is possible or embodies a suggestion for a line of action that, as a rule, requires supporting facts to enable the reader to understand the situation that is depicted. Informal reports that are not on engineering subjects are a part of the machinery of operation of many commercial organizations.

Fine distinctions cannot be drawn between the business correspondence of the engineer and informal reports, nor is it necessary to do so. The two merge into each other and there will be many borderline cases that might be called either.

The informal report is widely employed in the transaction of business between staff members in an engineering organization. A member of the staff wishes information on some phase of the work upon which another is engaged, and he writes for it. The recipient assembles the information, incorporates it in a letter of the proper form, and forwards it. The information is thus provided and not only that; enough supporting data have been furnished to permit a judgment as to whether the inquiry has been understood and answered correctly, which is an important consideration. Of course, in many cases the questions that arise in engineering organizations are of such a nature as to make it desirable to present the answer in a formal report.

Construction Supervision.—As an example of the way in which informal reports arise, consider the

following circumstances. A superintendent of construction may inquire of a resident engineer on a building job as to the materials on hand in a store-room, the amount of paint required to finish painting the structural steel, or the wages that must be paid to skilled labor. To all of these inquiries the usual reply is in the form of a letter report. However, the engineering executive might not be satisfied with the simple report that 30 gallons of paint will be needed to finish the job. He knows, perhaps, that the job has already received what was estimated to be the right amount of paint. But if the subordinate reports that 60 gallons has already been used and that two-thirds of the tonnage has been painted, also that the inspector insists on a consistency somewhat thicker than it has been customary to use because the specifications have a special provision on that point, then the executive may indulge in a few thoughts about the inspector, but he will not question the need for additional paint.

A superintendent of a generating station may receive a letter from the chief engineer of his company inquiring why the quantity of coal used at the plant is overrunning the preliminary estimates. The superintendent explains the several causes and the conditions that bring these causes into play. This constitutes an informal report.

The chief of the operating division of an industrial plant perhaps concludes from the daily reports received that the output of certain shops is not as high as it should be. He asks the resident superintendent for a detailed report on the situation. The report will set forth in a letter the various factors that serve to answer

the question: Why are you falling behind the production schedule?

An inspector may be sent out to investigate the suitability of the clay in certain deposits for the manufacture of ceramic wares. He samples and tests the material and forwards an informal report which concludes with his judgment as to the suitability of the material. But he includes enough test data to enable his superior to check the findings, and to provide a record for future reference.

Sales Routine.—In sales organizations, informal reports frequently pass between the salesmen and the sales manager. The sales manager may receive information to the effect that the Blank Manufacturing Company contemplates the purchase of a condenser. He writes one of his salesmen to call on the company and ascertain the facts. The salesman interviews the mechanical engineer of the company, learns the details of size, service, space available, and other pertinent facts, then writes a report to his chief which probably closes with a recommendation as to the model of condenser needed. But the report must furnish enough data to enable the engineering division of his company to check up on the size and type recommended, and the letter report is thus differentiated from the ordinary business letter.

A sales manager may receive a complaint that certain equipment that has been delivered is not functioning as the salesman represented that it would. The salesman is required to visit the dissatisfied customer, learn his reasons for complaint, and adjust the matter if possible. The salesman makes a report on his findings in the form of a letter, which is generally an

informal report but may be no more than a business letter.

Again, a sales manager may find that his product is not moving in a certain territory. A man is detailed to ascertain the reason for the condition. This man visits the territory and studies the market until he discovers the various causes for the lack of interest in the product. These are reported, together with recommendations or suggestions for improving the situation. This takes the form of an informal report except in those cases where it is necessary to make a long and exhaustive study before finding the answer, in which case the survey would culminate in a formal report.

Service Reports.—Another field in which informal reports are widely used is in connection with surveys undertaken to determine the character of the service being rendered by various engineering works. A company may be contemplating extensions to a plant located at a distance from its general office and, in planning the equipment, wishes to check up on the performance of certain units now in use. The plant superintendent is asked to report on the character and cost of service of the unit in question. He probably delegates the preparation of the report to the plant engineer, who furnishes the required statistics and a definite answer to the question.

Many manufacturers attempt to keep some contact with their equipment after it has reached a customer's plant. They cannot expect to check up on every piece but do secure service reports on representative installations. These reports are prepared by engineers in the sales or service departments of the organization.

The foregoing will perhaps indicate the way in which informal reports arise. Questions that can be answered briefly by a letter written in the first person with a minimum of supporting data are the basis of informal reports. If the question is of such a character that many data must be assembled before an answer can be formulated, then the formal type of report would probably be employed.

Two Controlling Features of Letter Reports

Adequacy.—The letter report must answer the questions that called for the report so fully as to be adequate for the purposes of the person to whom the report is addressed. To do so, the writer of the report should try to sense all of the implications of the question. Why was the inquiry submitted? What will be done about the matter when the report is received? Of course, it is not always possible for the writer to understand about these things and in those instances his report has to be written with a certain handicap.

When the question is not fully understood, which usually means it is not made definite enough, it may be wise to inquire further before attempting a reply, but this should be avoided whenever possible because in some organizations that might be considered an indication of inattention or lack of resourcefulness. In such cases the engineer must do the best he can on the basis of his understanding of the real import of the inquiry, and he ought to try to reason through to the probable situation if he can and make clear in his letter just what question he is answering.

Substantiation.—The report must contain enough data and explanatory material to show that probably

the correct answer to the question has been reached. The superior may be confident that his subordinate is fully competent to answer the question and will answer it correctly. But the report may be used in dealing with a third person who would demand reasons for the conclusions reached. The report should, therefore, furnish proof of the correctness of the conclusions. In addition, the report may be filed as a permanent record of the transaction and may at some future time be consulted by a person who was not familiar with the original correspondence.

In other instances a subordinate may not yet have established himself in the organization and his superior would, therefore, not yet know how dependable his reports could be expected to be. Data and supporting evidence are required so that the conclusions of the report may be evaluated by the superior. If these reports are complete and conveniently arranged, they create a favorable impression just as does any other well-performed task. The young engineer should strive to make each report a model because it may be the only evidence of fitness his superior will have an opportunity to see over a period of many months.

EXAMPLE OF A LETTER REPORT¹

GUSTAV LINDENTHAL
Consulting Engineer
New York City

26 Exchange Place
Jersey City, N. J.
October 6, 1930

Mr. E. M. Wichert,
35 Eastwood Road,
Wilkinsburg, Pa.

Dear Sir:

I have carefully examined, as requested, your system of statically determinate continuous truss or girder (steel) described in your application for patent, and also the able report thereon of Messrs. Robinson and Steinman, Consulting Engineers, in New York City. I have further made an independent analysis of the possible economies of your type of truss, as shown in different arrangements on the patent drawing, and compared these with the similar factors in simple trusses, then with the conventional continuous girder, and the cantilever types, to enable me to give you a well-considered opinion on its merits.

Omitting unnecessary recapitulation of the various advantages already stated and defined in the report of Robinson and Steinman, which I fully endorse, I recognize that your type of continuous girder is a step in progress and refinement in the design of metallic (steel) bridges, in that it skillfully utilizes the reaction from dead and live load on the piers for the purpose of greater rigidity and for the more definite ascertainment of the stresses in the truss members through the application of the simple method of the lever as used for simple trusses and cantilevers and which is in contradistinction from the orthodox conventional system of continuous girders, in which the stresses

¹STEINMAN, D. B., "The Wichert Truss," Appendix A, D. Van Nostrand Company, Inc., New York, 1932.

must be computed by the somewhat laborious method based on the theory of elasticity of the metal.

The better controllable results of computations permit of closer economy in the dimensioning of the cross sections for the truss members in your system, particularly, and those subject to reversional stresses from live load and temperature effect.

With this advantage over the orthodox continuous girder, your type shares, nevertheless, its distinctive virtue of great rigidity and less vibration under passing loads, as compared with the simple girder or the frequently wobbly cantilever.

Your system also offers the much-desired economy in bridging alluvial rivers where good foundations are often costly and where a saving in the weight of the superstructure, such as is possible with your type of truss, produces a corresponding saving in the cost of foundations and piers.

Another economy results from the feasibility of erection without falseworks and without additional metal (steel) in the trusses for merely erection purposes.

Finally, it should be stated that the best results with your type of truss will, of course, be obtained in each case by special analysis and study for fitting it to the local conditions, and I believe that it can successfully compete even for longer spans for which so far only the cantilever, arch and suspension types came under consideration.

Therefore I take pleasure in expressing my conviction that your type of continuous truss is a meritorious contribution to bridge construction, which will have frequent application for its economy and the various decided advantages above indicated.

Yours very truly,
(Signed) Gustav Lindenthal

CHAPTER III

PRELIMINARY PARTS OF FORMAL REPORTS

In the following sections there is presented a conventional arrangement for the formal engineering report and some explanation of the methods that are usually followed in determining what to include in each part and how to arrange the material to make it most effective.

Literary Form.—The literary form that is accepted as correct for the formal engineering report is fairly definite although many reports conform only loosely to the general pattern. The orthodox report consists of certain elements arranged in a sequence that is intended to facilitate rapid assimilation, but there are engineers who do not follow such a form and yet produce reports that are recognized as authoritative and acceptable. A conventional arrangement has gradually evolved because it contributed to clearness, ease of reading, convenience in filing and indexing, and economy of effort in preparation. It is quite evident that, as the art of report writing has progressed and the reasons for the accepted forms have become apparent, there has been a gradual drift toward the adoption of a certain form of presentation. The outline suggested in this treatise is not universally accepted but, in essence, is followed rather closely. It is not the only arrangement that is permissible,

although it is one that is widely used and seems to meet the requirements very satisfactorily.

The elements of the engineering report of the form presented herein were listed in order at the end of Chapter I. These will now be discussed in detail.

Title Page

Elements of a Title Page.—The orthodox title page is made up of the following elements:

1. The title of the report.
2. The name of the author and his official title (if any).
3. The name or designation of the person or group for whom the report was prepared (omitted on title pages of many research reports).
4. Place and date information.
5. The auspices under which the report is issued (sometimes).

Design of the Title.—The selection of an appropriate wording for a title may be simple or complicated, depending upon the nature of the report. It is apparent that the title ought to tell rather definitely what the report deals with and in certain instances that is not easily accomplished within reasonable length. The title should not be too long because that tends to defeat the purpose, which is to indicate the contents of the report with sufficient brevity that it can be read by a cursory glance. In case of doubt, it is better to err on the side of definiteness than on the side of brevity.

The title is usually placed in the upper third of the title page and frequently is the upper element of the page. In certain types of research bulletins and

**IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS
OFFICIAL PUBLICATION**

Vol. XXX

APRIL 6, 1933

No. 45

LOADS ON PIPE IN WIDE DITCHES

By **W. J. SCHLESCH**



Bulletin 108

**IOWA ENGINEERING EXPERIMENT STATION
IOWA STATE COLLEGE
AMES, IOWA**

Published weekly by Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa.
Entered as second-class matter and accepted for mailing at the special rate of postage provided for in Section 435, P. L. & M., Act of August 24, 1912, authorized April 13, 1933.

FIG. 1.—Example of a title page for a research report.

BULLETIN 108

IOWA ENGINEERING EXPERIMENT STATION

LOADS ON PIPE IN WIDE DITCHES

By W. J. SCHLICK
Drainage Engineer



IOWA STATE COLLEGE
AMES, IOWA

Vol. XXX

APRIL 5, 1932

No 45

FIG. 2.—Example of the inside title page of the research report for which the title page is shown in Fig. 1.

in the reports issued by a good many boards or commissions, the auspices under which the report is issued is frequently indicated at the top of the title page, followed by the title proper.

After the wording for the title is selected, the arrangement into typographical form is a matter of design. The guiding principles are appropriate emphasis of important words in the title and a pleasing appearance. The title should be suitably placed on the page, being neither too near the top of the page nor too near the mid-height. The words in the title should balance across the page; and if the title is too long for a single line, the lines should break after significant words. It is not good taste to flank important words in a line with an unimportant word such as an article or a preposition.

Examples of Title Design.—Supposing the title of a report were "Determination of Soluble Bitumen in Asphalt," this might be written in several ways and four are shown below:

(A)

REPORT

on the

**DETERMINATION OF SOLUBLE BITUMEN
IN ASPHALT**

(B)

REPORT

on the

**DETERMINATION OF SOLUBLE BITUMEN
in
ASPHALT**

(C)
REPORT
on the
DETERMINATION OF
SOLUBLE BITUMEN IN ASPHALT

(D)
REPORT
on the
DETERMINATION
of
SOLUBLE BITUMEN IN ASPHALT

The forms given above will serve to illustrate several points in connection with the design of titles. The first is: try to keep significant words in a single line or in two or more balanced lines. In the title under consideration, assume that the basic idea it is desired to convey is that the report deals with *methods for the determination of soluble bitumen*. Therefore, the words "determination of soluble bitumen" are most appropriately placed in one line, as in (A) and (B). The words "in asphalt" might be used for a final line of the title as in arrangement (A), but that is contrary to the notion that a principal line in the title should neither begin nor end with an unimportant word. Form (B) shows an arrangement that is perhaps better than that shown in (A).

If the emphasis of the report is on the *determined* quantity of soluble bitumen in asphalts rather than upon *methods* of determination, then the words "soluble bitumen in asphalt" should be in a single line as shown in (C) and (D). Here again the choice of the

REPORT
RELATING TO
TROLLEY CONSTRUCTION
UNDERGROUND CONDUIT
CONSTRUCTION
AND
SUBWAYS

SUBMITTED TO
THE COMMITTEE ON LOCAL TRANSPORTATION
OF THE
CHICAGO CITY COUNCIL
BY
BION J. ARNOLD
JULY 2, 1906

ARNOLD REPORT No. 9

FIG. 3.—Title page for a report preliminary to construction.

four-line or five-line title is to be considered. If four lines are used, the third will end with "of," an unimportant word. Form (D) is free from that objection.

The title might then be as in (B) or (D), according to the phase of the report that is to be emphasized. If *method* is being reported upon, use (B); if the *result* of determination is the meat of the report, use (D).

Another illustration of title design may be of service. Assume the title of a report to be "Tractive Resistance and Related Characteristics of Roadway Surfaces." The report obviously deals with *tractive resistance* and with *related characteristics*, but a title in which the whole subject is stated in a single line would not have a good appearance. Therefore, the title would probably be designed as follows:

TRACTION RESISTANCE
and
RELATED CHARACTERISTICS OF ROADWAY
SURFACES

It is intended that the title should really tell what the report is about, not merely indicate the subject in a general way. In not a few instances the subject of a report requires so long a statement that it is difficult, if not impossible, to break it up into balanced lines that carry the meaning. In such instances it is customary to make the lines of the proper length to balance on the page and run the title continuously to the end, as illustrated by the following:

(A)

REPORT

on the

**DETERMINATION BY CHEMICAL ANALYSIS OF THE
PORTLAND CEMENT CONTENT OF SAMPLES OF
CONCRETE FROM THE BASE COURSE OF
BRICK PAVEMENTS IN THE VILLAGE OF
ANITA, IOWA**

(B)

REPORT

of the

**ENGINEERING BOARD OF REVIEW OF THE
SANITARY DISTRICT OF CHICAGO ON THE
LAKE LOWERING CONTROVERSY AND A
PROGRAM OF REMEDIAL MEASURES**

It should be apparent that the design of a balanced title when the subject is of this character is difficult and it would seldom be attempted. However, it is not impossible and the following will indicate the result of such an attempt with title (B). It is not a very effective title.

REPORT

of the

ENGINEERING BOARD OF REVIEW

of the

SANITARY DISTRICT OF CHICAGO

on the

LAKE LOWERING CONTROVERSY

and a

PROGRAM OF REMEDIAL MEASURES

PRELIMINARY PARTS OF FORMAL REPORTS 37

Statement of Authorship.—The second item of the title page gives the authorship of the report and generally follows the title proper, usually preceded by the word “by.” The official title of the author of the report is quite frequently given although in some instances it is omitted. It is desirable in many cases to indicate the capacity in which the writer prepared the report, and also to indicate in a measure the degree of authority that may be assumed for the report.

Addressee.—The third important item on the title page is the name of the individual, corporation, or official body to which the report is addressed. This information follows the title and is subject to the same principles. The information should be set forth fully and in a carefully balanced line or two as may be required. Two examples may suffice to indicate what is customary.

To the
EXECUTIVE COUNCIL
of the
STATE OF IOWA
To
RAYMOND T. BROWN
PRESIDENT, ENCO PRODUCTS, INC.

In reports made to public bodies, it is not unusual for the order of these two items to be reversed, the name of the body to whom the report is addressed being given precedence over the name of the person or organization by whom the report was prepared.

Place and Date.—The final item on the title page is the statement of the place and date of issue. The

**A METHOD OF MAKING SHORT TRAFFIC
COUNTS AND ESTIMATING TRAFFIC
CIRCULATION IN URBAN AREAS**

By

FRANZ A. AUST

Associate Professor of Landscape Design

H. F. JANDA

Professor of Highway Engineering and City Planning

Assisted by

JOHN R. CAMPBELL

Barney Link Research Fellow—1924-28

ROBERT S. HARRISON

Barney Link Research Fellow—1929-30

UNIVERSITY OF WISCONSIN

1931

FIG. 4.—Title page for a research report.

REPORT
OF A
SURVEY OF TRANSPORTATION
OF THE
STATE HIGHWAYS OF PENNSYLVANIA

BY
THE BUREAU OF PUBLIC ROADS
U. S. DEPARTMENT OF AGRICULTURE

AND
THE DEPARTMENT OF HIGHWAYS
OF THE
COMMONWEALTH OF PENNSYLVANIA

1928

FIG. 5.—A nicely balanced title page.

date line, of course, is exceedingly important and should always appear. It is customary to precede the date line with the name of the place of issue.

When a report is prepared by some member of the staff of a government or state bureau, it may be issued as one number of a bulletin or circular series. In such instances the auspices under which the report is used will be indicated on the title page, usually at the top of the page, but sometimes at the bottom. If the publication is listed for the second-class mailing privilege, the notice prescribed by postal regulations will follow the statement showing the auspices under which the report was issued.

When the title page is repeated on the first page inside the cover, it is usually identical with that appearing on the cover except that it is not customary to repeat the portion of the cover title page that indicates the auspices under which the report was prepared. Some examples of title page design are shown in Figs. 1 to 5.

Letter of Transmittal and Preface or Foreword

Letter of Transmittal.—When an engineering report is prepared by a subordinate bureau, the chief thereof generally transmits the report to his superior for action. The formality by which this is done consists in forwarding the report with a letter of transmittal. If the report passes between consultant and client or subordinate and chief in an organization, the same custom is followed. The letter of transmittal consists of a brief business letter stating that the report is being forwarded and perhaps a recommendation as to its disposition. It may be recommended for publication,

for example. The letter of transmittal is no more than a formal method of introducing the recipient to the report with perhaps a few words as to the reason for there being such a report. Considerable latitude exists as to the content of the letter of transmittal but as a rule it is brief and formal. In some instances the engineering report will carry two letters of transmittal, the person to whom the report is first presented transmitting it to some other person by means of a second letter. It is more common, however, for such a person to drop the letter by which the report was transmitted to him and substitute a new letter telling that he has received the report from a certain subordinate and is sending it on. In some instances the services of assistants who have worked on the report are acknowledged in the letter of transmittal, but more often this is done elsewhere in the report.

Preface or Foreword.—Some research reports are published with a preface or foreword in lieu of, or in addition to, a letter of transmittal. Reports published for the general information of the profession need a brief explanation of the author's reasons for thinking the report to be of value and perhaps some explanation of how he happened to write the particular one.

Where the preface is used instead of a letter of transmittal, it is quite customary to include acknowledgments therein. Examples of the preface, the foreword, and the letter of transmittal follow.

AN EXAMPLE OF A PREFACE AND OF A
FOREWORD

PREFACE

THE present publication treats of a subject with which the Carnegie Foundation for the Advancement of Teaching has dealt since 1923, the relation of college and school athletics to the educational process. It insists, perhaps more clearly than any previous discussion published by the Foundation, that final responsibility for the effective administration of American college sport belongs not to the alumnus, the down-town business man, or the newspaper writer, but to university or college officers.

The principle has long been recognized, but not always acted upon. The result has been much administrative confusion and—still more unfortunately for our nation—a serious impairment of the product of our secondary and higher education. This impairment affects directly the contribution the graduates of our colleges and universities have been able to make to our national life. It is somewhat reassuring to note that many of the changes summarized in the present Bulletin point to an improvement in this respect, both immediate and future.

I take this opportunity to thank the officers and teachers of cooperating institutions, American, Canadian, and British, who by their interest and patience have furthered the enquiries of the Foundation into college sport in these nations.

HENRY SUZZALLO

April, 1931

FOREWORD

This report contains the results of highway traffic studies of the State primary, secondary and State-aid road systems of Pennsylvania conducted during 1924 under a cooperative research agreement between the Bureau of Public Roads, United States Department of Agriculture, and the Pennsylvania Department of Highways.

This investigation was undertaken in order to obtain essential facts concerning traffic on Pennsylvania highways as a basis for their future development.

The first part of the report contains a summary of the principal conclusions and the second part the evidence upon which the findings of the report are based.

The researches were conducted under the joint supervision of Thos. H. MacDonald, Chief of the Bureau of Public Roads, and W. H. Connell, who until May 1, 1927 was engineering Executive and Deputy Secretary of Highways of the Pennsylvania Department of Highways. Publication of the report has been completed under the administration of James L. Stuart, Secretary of Highways and Samuel Eckels, Chief Engineer.

J. Gordon McKay, Chief of the Division of Highway Economics, Bureau of Public Roads, directed the work of the survey and preparation of the report, assisted by O. M. Elvehjem, Highway Economist, E. T. Stein, L. E. Peabody and B. P. Root, Associate Highway Economists, all of the Division of Highway Economics in cooperation with W. A. Van Duzer, Assistant Chief Engineer, J. W. Follin, Office Engineer, and H. K. Craig, Cost Engineer, all of the Pennsylvania Department of Highways.

EXAMPLES OF LETTERS OF TRANSMITTAL

IOWA
STATE DEPARTMENT OF HEALTH
Walter L. Bierring, M. D., Commissioner
Des Moines

July 31, 1935.

W. L. Bierring, M. D.,
Commissioner,
State Department of Health,
Des Moines, Iowa

Dear Dr. Bierring:

I am transmitting herewith the report of your Division of Public Health Engineering covering the investigations of the pollution of the Des Moines River from a point above Estherville, Iowa, to Farmington, Iowa.

These investigations were instituted in 1928 at the direction of Dr. Henry Albert, former Health Commissioner, and were continued at your direction as provided for under Sections 2198 to 2209, Code of Iowa, 1931.

Respectfully submitted,
A. H. WIETERS, Director,
Division of Engineering.

Pawtucket, R. I., January 1, 1932.

To His Honor the Mayor, and the Honorable City Council:
Gentlemen:

I have the honor to present herewith, in accordance with the provisions of the city ordinances, the thirty-eighth annual report of the Board of Public Works, for the year ending December 31, 1931.

Respectfully submitted,
HERBERT A. FULLER,
Commissioner of Public Works.

5 GEORGE V. SESSIONAL PAPER No. 25c A. 1915

DEPARTMENT OF THE INTERIOR,
Irrigation Branch,
OTTAWA August 14, 1915.

W. W. CORY, Esq., C.M.G.,
Deputy Minister of the Interior.

SIR:—

I submit herewith the report of Stream Measurements for the year 1914, submitted by F. H. Peters, C.E., Commissioner of Irrigation, and would recommend that it be published.

Respectfully submitted,
E. F. DRAKE,
Superintendent of Irrigation.

DEPARTMENT OF THE INTERIOR,
IRRIGATION OFFICE,
CALGARY, ALBERTA, July 30, 1915.

E. F. DRAKE, Esq.,
Superintendent of Irrigation,
Department of the Interior,
Ottawa, Canada.

SIR:—

I have the honour to transmit herewith the manuscript of the Report of the Progress of Stream Measurements for the calendar year 1914. This report has been prepared, under my direction, by P. M. Sauder, M. Can. Soc. C.E., Chief Hydrometric Engineer, G. H. Whyte, and G. R. Elliott, B. A. Sc.

I beg to recommend that it be published as the sixth of the series of Reports of Progress of Stream Measurements.

I have the honour to be, Sir,
Your obedient servant,
F. H. PETERS,
Commissioner of Irrigation.

DEPARTMENT OF THE INTERIOR,
IRRIGATION OFFICE,
CALGARY, ALBERTA, July 29, 1915.

F. H. Peters, Esq., M. Can. Soc. C.E.,
Commissioner of Irrigation,
Department of the Interior,
Calgary, Alberta.

SIR:—

I beg to submit herewith the manuscript of the Report of Progress of Stream Measurements for the calendar year 1914.

Owing to the fact that much of my time has been taken by other duties, most of the work of preparing this report has fallen to my assistants, G. H. Whyte and G. R. Elliott, B.A. Sc. The report gives a brief outline of the methods of obtaining and compiling the data contained therein, but owing to the want of space and time, many of the details had to be omitted. There is given in tabulated form all the records of stream flow.

I beg to recommend that this report be published as the sixth of the series of Reports of Progress of Stream Measurements.

I have the honour to be, Sir,
Your obedient servant,
P. M. SAUDER,
Chief Hydrometric Engineer.

January 5th, 1928.

Colonel Sidney D. Waldon, President,
Colonel H. W. Alden, Vice-President,
Mr. Willard Pope,
Mr. C. W. Hubbell,
Mr. A. H. Green, Jr.

Rapid Transit Commission,
City of Detroit,
Michigan.

Gentlemen:

The attached study of the relation of passenger transport in private automobiles (or individual transportation) to passenger

transport in public vehicles (or collective transportation) may serve to give a clearer view of the importance of the automobile as a transportation unit and the physical limitations imposed upon its use in large cities by existing street systems.

It may also serve to accentuate the necessity of carrying on with the work of acquiring right of way for the thoroughfares of the Master Plan as an indispensable element in providing for the freedom of movement of all surface traffic, as well as the most economical provision for extension of rapid transit lines within the present and future limits of the City of Detroit.

Respectfully submitted,
DANIEL L. TURNER,
Consulting Engineer.

J. P. HALLIHAN,
Chief Engineer.

Table of Contents

The purpose of the table of contents is to facilitate reference to the report and to show in a broad way the type and range of subject matter covered. The title can do no more than give the subject of the report but the table of contents indicates the scope and character of the subject matter. This affords a key to the desirable arrangement of the table of contents.

Items Included in Table of Contents.—As a rule, the titles of the chapters of the report constitute the main items of the table of contents. If a report is too short to be divided into chapters, it will be divided into major subdivisions which are set out in the report by appropriate typography. These divisions may be indicated as sections or merely set out by paragraph or center headings. In any case these will be items for the table of contents,

and when the report is relatively short it probably is not necessary to go into any greater detail with the table of contents. If the report is very long, it is desirable to include in the table of contents the main headings, which may be sections or chapters, and the principal subdivisions thereof. It is permissible to give the page reference to each item in the table of contents, which differs from book practice.

The table of contents is essentially an outline of the report and the extent to which subdivisions are employed in the table is largely a matter of the judgment of the writer. If a report is long and involved, it is well to list major divisions and major subdivisions in the table of contents. In other instances the length of the report and the nature of the arrangement of the subject matter are such that the table of contents needs to include only the major divisions of the subject.

The following examples of the table of contents will illustrate acceptable practice.

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¹ Cooley, Lyman E., "The Illinois River," *Bull., Sanitary District of Chicago, Chicago, Ill., Aug., 1914.*

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¹ Wieters, A. H., "Investigation of Pollution of the Des Moines River from Estherville to Farmington, 1928-1934." State Department of Health, Des Moines, Iowa, 1934.

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¹ "Third annual report of the Federal Power Commission,"
U. S. Government Printing Office, 1923.

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Abstract or Synopsis

The abstract is a summing up of the findings of a report, to be presented ahead of the main text of the report to show the nature of the report more fully than is accomplished by the table of contents and to give some inkling of the trend of the conclusions that were reached. It is a relatively brief summary of the main facts presented in the report and of any conclusions drawn or recommendations offered. The abstract may be a single paragraph or it may cover several pages, depending upon the length and complexity of the report itself.

The purpose of the abstract is to enable the busy reader to gain quickly an idea of the meat of the report. It may be assumed that his curiosity is aroused by the title, is increased by reading the table of contents, and is either satisfied by reading the abstract or still further increased so that he decides to read the whole report. At the moment the reader may not be interested in the accumulated facts represented by the data and the manner in which they were secured or the conclusion reached. Another reader may be interested in the assembled data and not the conclusions, and the abstract will tell him what will be found in the report. The abstract should be made as short as is consistent with this purpose.

EXAMPLES OF THE ABSTRACT

I

Experience gained from nearly three years' operation of the large single-ended stokers at Delray has led to developments and improvements in design, the application of which has made them comparable with other types of coal-burning equipment. Improvements have been made with two things in mind—namely, an increase in efficiency of combustion and a reduction of maintenance by decreasing burned stoker parts. All improvements possible, particularly those to improve combustion, have not as yet been completed; however, changes that have been incorporated have materially improved performance. Automatic control of preheated air to the various parts of the fuel bed has been sufficiently developed to establish it as a desirable and valuable aid to combustion, particularly with long stokers burning high-volatile coal. One of the stokers has been operated successfully for a short period with preheated-air temperatures as high as 500 °F. Development of a similar air-control system, manually operated, under two boilers in the Beacon Street Heating Plant, handling cold air, has resulted in an increased steaming capacity of 31 per cent and an increase in calculated boiler efficiency of from $\frac{1}{2}$ to 2 per cent. The paper is a description of the Delray installation, but reference is made to the large double-ended stokers, supplied with cold air, and the manually operated metered air control in the Beacon Street Heating Plant.¹

¹ Thompson, Paul W. and Fred J. Chatel, "Stoker Developments at the Detroit Edison Company's Delray Power House No. 3," *Trans. American Society of Mechanical Engineers*, Vol. 55, 1933, F.S.P. 11, p. 171.

II

The equipment and methods of raising and moving twelve miter-gate leaves of the Panama Canal, at Miraflores, are described in this paper. Considerable wear on the vertical bearing surfaces made replacement advisable. The quoin-bearings could be made accessible only by raising the leaves clear of the pintles and moving them from the wall. The largest leaves are 82 ft. high and have an estimated gross weight of 790 tons.

Comparisons are made between the experimental equipment and the methods used at Pedro Miguel, in 1929, and the present system. Improvements in technique, suggested by experience gained in raising twenty-two leaves during three over-haul periods, are emphasized.¹

¹ Morse, Clinton, "Renewal of Miter-Gate Bearings, Panama Canal," *Proc. American Society of Civil Engineers*, Vol. 60, No. 1, Jan., 1934, p. 37.

CHAPTER IV

THE MAIN PARTS OF FORMAL REPORTS

The main body of the formal report consists of several parts, each of which is related to the other parts but is distinct as regards subject matter and treatment. The writer first makes a clear statement of just what the report is intended to cover. He then tells how he went about obtaining the data needed to enable him to write a report of the kind he had undertaken. The facts relating to the problem are then marshalled, analyzed, and interpreted. This may lead to conclusions, strong indications, recommendations, or admission of failure to solve the problem.

Statement of the Problem.—At the outset, the author generally presents a clear, concise statement of the reason for the report. If he has received a definite commission, he may quote from the letter of appointment. This will often be supplemented by a statement of the exact field covered in the material presented. When the report is undertaken without a definite commission, as in research reports, the occasion for doing the work will be explained and the limitations clearly defined. The following statement of a problem appears in a report on certain features of the design of overhead crossings:

The questions considered in this report are as follows: If over-crossings for the separation of highway and railroad crossings are to be provided as shown by the plans for Crossing No. 110, at Deer Creek, L. I., in which the high-

ways are carried over the main line of the Long Island Railroad, are there substantial advantages in providing 5 percent approach grades rather than 6 percent approach grades, and likewise are there substantial advantages in providing a sight distance of 400 feet rather than a sight distance of 250 feet?¹

The purpose is to make clear just what problem the writer set out to solve or the question or assignment that sets the limitations of the report. If the conditions under which the report was written limit the character or completeness of the solution to the problem, the nature of the limitations and their bearing on the results will be explained. The following statement sets the limitations of a certain research report:

The problem of the rational design of pipe sewers as to structural strength to carry loads due to or transmitted through ditch filling involves the solution of three problems:

First, the problem of determining the ordinary maximum loads on pipe in ditches due to or transmitted through ditch filling, under different conditions as to methods of construction and character of ditch filling material.

Second, the problem of determining the actual "ordinary supporting strengths" developed by specific sewer pipe under "ordinary" pipe-laying conditions, and the definite ratios thereto of the actual supporting strengths developed by the same or closely similar pipes under different pipe laying conditions.

Third, the problem of developing standard methods of testing the strength of sewer pipe whereby the "ordinary supporting strengths" of specific sewer pipe can be determined definitely.²

¹ From the files of the authors.

² Marston, Anson, W. J. Schlick, and H. F. Clemmer, "The Supporting Strength of Sewer Pipe in Ditches," *Bull.* 47, Iowa Engineering Experiment Station, 1917, p. 5.

A design may be limited by the necessity of providing a plant or structure within certain budget allotments, or the development of a natural resource may be circumscribed by state or national laws. The type of structure may be greatly influenced by availability of materials. If for any reason the engineer must work within certain limitations (and he usually does), his report must make clear what these were. Two statements of problems follow to illustrate this situation.

I

The object of this paper is: (1) To outline and to interpret the result of full-sized tests on a steel sheet-pile bulkhead, particularly in regard to the effective, passive resistance of sand and the interlock efficiency of deep-arch sheet-piling; (2) to offer suggestions pertaining to a possible stress distribution in the passive prism between the wall and the surface of rupture; and (3) to present a new theory of the stability of bulkheads, which takes into consideration the elasticity of both wall and soil and which treats the problem as statically indeterminate.¹

II

1. Supreme Court Decision.—The decision of the United States Supreme Court on January 5, 1925, in the case of the United States against the Sanitary District of Chicago brings to the front for prompt decision a number of highly important engineering problems. While these have generally been considered independently, they must now be considered collectively. Under these circumstances no

¹ Bauman, Paul, "Analysis of Sheet-Pile Bulkheads," *Proc. American Society of Civil Engineers*, Vol. 60, No. 3, March, 1934, p. 289.

solution of the immediate question of what is the best use of the Chicago Drainage Canal can possibly be equitable which does not settle at the same time the regulation of the water levels of the Great Lakes, in the interests of navigation and water power development, and the policy to be adopted regarding navigable waterways from the Great Lakes to the Mississippi and Ohio Rivers. There are very few public problems of greater importance, more beneficial to so many people if wisely solved, before the United States today.

2. Other Matters Depend Upon Amount of Diversion.—

The determination of the quantity of water that shall be permitted to pass from Lake Michigan into the Drainage Canal is merely a detail in this greater problem of deciding how the Great Lakes can be best utilized for the benefit of the United States and the Dominion of Canada. It is a key detail, however, and if it be insisted that the diversion of water through the Canal must now be fixed irrevocably, then the Great Lakes and the Lakes-to-Gulf Waterway problems must be settled at the same time. Otherwise the decision is likely to prove inequitable and be followed by prolonged controversy and hardship to many persons and interests.¹

Definition.—In report writing it often proves desirable to define certain terms, such as those designating a piece of equipment, a process, a material, or a test. A definition is a "picture in words of the thing described" but the words employed must be those whose meaning may be expected to be understood by the reader. The definition is really a very concise description of something but is not always a good substitute for a description. In many instances a defini-

¹ "Report of the engineering board of review of the sanitary district of Chicago on the lake lowering controversy and a program of remedial measures," Part II, Jan. 23, 1925, p. 1.

tion adequate for report purposes can be accomplished only by a careful description.

In formulating a definition, it is well to prepare first a statement of every positive attribute of the thing defined, that is, everything it *is*. That statement should then be checked and modified, if necessary, to exclude everything it *is not*. Finally the definition should be scrutinized to make sure that all the words that have been employed are likely to be fully understood by the reader.

The engineer is likely to find occasion to write any one of three types of definitions, each type requiring a distinct style of phraseology.

1. Definitions recommended for use either in construction contracts or in general standard specifications should be written in semi-legal phraseology that covers the subject in minute detail. Such definitions may become the basis of litigation and subject to court interpretation and therefore ought to be written with exactness and on the assumption that interpretation will be based wholly on the wording, without any background of technical knowledge of the subject.

2. Definitions employed in reports passing between engineering personnel need be only sufficiently exact to be clear to a reader who has a knowledge of the subject and needs to be informed only as to the precise sense in which the defined term is employed in a particular report.

3. Definitions employed in reports that will be studied by persons outside the engineering profession should be written in simple non-technical phraseology that will picture broadly the thing defined rather than present a detailed working drawing.

Report writers also have occasion to employ definition of a somewhat broader character than that described above. This arises in defining such things as the subject of a report, the scope of a test, the basis of a design, or the limitations of a plan proposed for the organization of a factory. Here the problem is one of making clear, through careful description, the boundaries of the subject within which the report is confined. This should be done with certainty, precision, and brevity.

When terms, or the limits of a proposal, have been defined, the resulting statement may be checked for adequacy by determining whether it meets these requirements:

1. Does it specify all essential attributes of the thing defined?
2. Can anything meet the definition other than the one thing defined?
3. Have any words been used in the definition that of themselves might not be correctly understood by the persons who are expected to read the definition?

Note: A good test for a definition is to ask an associate to read it and then ascertain what he thinks it means.

Methods of Attack.—The method adopted for developing the facts needed for the solution of the problem is next explained. Arguments may be advanced to show why a particular method was preferable to some other. Several possible methods of attack may be reviewed and their relative usefulness in the particular case debated. The important consideration is to make clear the reason why the data

for the report were obtained and used in a particular way. Perhaps this was not deemed the best way in some cases but was adopted for very good reasons and these should be set forth to forestall possible criticisms.

In some cases it is most convenient and illuminating if the method adopted for developing the data is combined with the discussion of the data. Such a plan is followed rather widely, especially in the reports that run to considerable length. Even in such cases it aids materially if a brief statement of the method of attack is presented early in the report. Some reports are of such a character that several lines of attack are necessary, each of which involves an elaborate organization for the fact-finding process. To explain such a plan independently of the presentation of the data that are assembled would require useless repetition and should not be attempted.

Apparatus and Equipment.—If measurements, analyses, surveys, or tests were made, the methods employed and the instruments used should be described in detail. This will tend to establish the reliability and comprehensiveness of the results obtained. In those instances where nationally recognized standard methods of analysis or testing are followed, the mention of the particular method by its official title is sufficient. If specially designed apparatus or new methods of observation or testing are devised, these should be described in detail.

The following extract will illustrate what is desirable:

Truck swing and drawbar angle were measured only on the Mikado electric locomotives. The term "truck swing" signifies the lateral displacement of the frame of the two-

wheel guiding truck relative to the main frame of the locomotive. The term "drawbar angle" signifies the angle formed by the longitudinal center line of the drawbar with respect to the longitudinal center line of the locomotive. The apparatus employed for recording these measurements was mounted on the locomotive and continuous records of both truck swing and drawbar angle were obtained over the entire electrified section, that is, from Wenatchee to Skykomish.

Truck swing and drawbar angle were both measured with the same apparatus, which is shown diagrammatically in Fig. 66. This apparatus consisted essentially of a potentiometer, two Esterline-Angus recording voltmeters with their drums locked together, and a storage battery. The arm of the potentiometer was displaced in one direction by a steel cable and in the reverse direction by a coil spring. The recording voltmeters made their records on a moving roll of paper.

For the truck swing measurements, a potentiometer was mounted on the frame of each of the two two-wheel guiding trucks under one cab. On each truck, the steel cable actuating the potentiometer arm was connected to the bottom pin of the heart link nearest the potentiometer. The bottom pins of the heart links move with the main frame of the locomotive, hence the displacements of the potentiometer arms were proportional to the displacements of the frames of the guiding trucks relative to the locomotive main frame. The voltage on each potentiometer was given a value such that one main division on the recording paper was equal to one inch truck displacement. Simultaneous records were obtained for the two trucks of one cab.

For the drawbar angle measurements, the potentiometer was mounted on the locomotive main frame and the steel cable connected to the drawbar at a distance of about 2 ft. from its pivot point in the locomotive main frame. The potentiometer voltage was adjusted to a value such that

one main division on the recording paper corresponded to an angle whose tangent was 0.02. Simultaneous records were obtained for the two drawbars on one cab.¹

Assembled Data.—A summary of the pertinent data that have been assembled is given next to show the basis for the conclusions reached. Generally speaking, all data that are secured are actually given or referred to in the text of the report. Voluminous tabulations, calculations, or other like data may be included in appendices, and summaries only included in the body of the report. In the main body of the report there appears that material which is relied upon to substantiate the conclusion of the report, or which is the basis of the recommendations submitted. The various methods employed for presenting data will be discussed in another place.

Analysis of the Data.—It does not always happen that the answer to the question propounded is directly evident from the data which have been collected. Usually these data must be analyzed and interpreted before a solution is found or a conclusion reached. This will be discussed in detail later.

Recommendations or Conclusions.—The final section of the main body of a report contains the answer to the question or the solution to the problem that is the occasion for the report. This answer may be in the form of data, as in a report on a test; it may be a design; or it may be a recommendation as to some particular course of action. The answer may be in

¹ Shamburger, J. P. and B. F. Langer, "Rail Stresses and Locomotive Tracking Characteristics Found in Tests on Great Northern Railway," *Bull. 339, American Railway Engineering Association*, Sept., 1931.

the form of conclusions as to cause in the case of an investigation of an accident. Whatever form it chances to take, this portion of the report is of necessity the logical outgrowth of what has preceded. Otherwise the whole document loses its value.

Certain reports are prepared for the sole purpose of giving information as to the physical make-up of a plant or the condition of a structure or for some similar purpose. Here there is no problem to solve and it is not customary to sum up the findings in such cases. There may be a final section of general remarks to give a neat finish to the report but this is not always done.

The following example indicates a common and desirable method of stating in a report the conclusions that have been reached:

From evidence presented in this paper, the writer has come to the following conclusions:

1. The arched column principle presents a simple and exact means for designing buttressed dams of uniform strength.

2. In case of monolithic buttresses designed by this method the first principal stress is constant compression and the second principal stress is zero.

3. Secondary stresses are practically eliminated by building the arched columns as independent, statically determinate units, separated from each other by continuous joints extending through deck and buttress system and complete enclosure of the dam.

4. The buttressed dam of uniform strength contains the minimum possible amount of material that can be obtained with a given design stress.

5. The exact quantities and design elements can be obtained from diagrams, in which the main variables are expressed as pure ratios.

6. The independent arched column units permit construction of the dam in economical steps at long-time intervals—no anchorage between the old and new concrete is required, and spillway facilities may be incorporated in each step with no waste of materials for this purpose.

7. The buttressed dam of uniform strength is superior in safety and economy to the gravity type for any height to which a concrete dam can be built.¹

Appendices.—It has already been mentioned that statistical or descriptive material too voluminous to be included in the body of the report is placed in an appendix so that it is available for reference. If several kinds of such material are included, each is made a separate appendix. Thus stream gagings taken in connection with a survey for a bridge might be in one appendix and rainfall data in a second, while the calculations used in the design would be in a third. These appendices correspond to enclosures in a business letter.

Index.—If a report exceeds twenty typed pages, an index is a convenience to the reader. The form is that used in the technical treatise of book form. Examination of a few textbooks will indicate the usual arrangement.

¹ Schorer, Herman, "The Buttressed Dam of Uniform Strength," *Trans. American Society of Civil Engineers*, Vol. 96, 1932, p. 666.

CHAPTER V

COLLECTION OF DATA FOR REPORTS

When an engineer finds himself confronted with the opportunity of preparing a technical report for a client, or by way of a contribution or a discussion for a technical society meeting, or for publication in a technical periodical, he immediately begins to take stock of the situation with a view to getting together the facts that will afford a basis for the adequate treatment of the subject. In most instances opportunity has come to the particular engineer because he has an established reputation in the particular professional field or one closely related to it. Consequently it may be assumed that in most instances he already knows a great deal about the subject upon which he proposes to write. But if he is desirous of preparing a comprehensive treatment of the subject, he will wish to gather together all of the facts available to him that have a bearing upon the particular subject with which he is to deal.

It often happens that the nature of the assignment is such that the engineer finds himself already in possession of sufficient information on the subject to permit him to make a complete and accurate analysis and solution of the problem. This is usually true when an engineer has been for a number of years engaged upon some professional work of considerable magnitude, during which time he has made

exhaustive studies of all of its ramifications and has collected a large amount of technical data relating to the subject. Frequently he will be called upon to prepare a report upon some one phase of the work, and in such cases it will only be necessary for him to select from the material at hand what is pertinent to the particular part of the problem he intends to discuss. In many cases the informal report is prepared almost wholly on the basis of the information already possessed by the writer, although occasionally it may be necessary to secure additional information on some point in connection with even the simple questions that are the basis of the informal reports. In other cases a good deal of study and the assembling of considerable data will be required for formal reports and even for informal reports.

Appraising the Situation

Plan a Program of Study.—If the assignment is the preparation of a technical report for a client who wishes the answer to some engineering question, it is particularly desirable to present an array of facts that will be wholly conclusive, if that proves to be possible. Therefore, the first step in the preparation of the report is the planning of a program of study and the collection of facts, usually in the form of technical data, upon which the analysis of the problem will be based. The scope of this program will depend largely upon the complexity of the problem and the familiarity of the particular engineer with its different aspects.

A great many engineering reports arise in cases where it is necessary for the engineer to gather together

information from several sources before he is prepared to write the report. Quite frequently the assignment will involve the making of field examinations, surveys, and laboratory tests to secure the basic facts needed. Each engineer who finds himself confronted with a problem of this sort will develop a program of study according to his own convenience and the necessities of the particular situation. There is no set method by which this sort of work can be scheduled, but in the discussion that follows a method will be outlined which will indicate the nature of the task and certain sources of information which are usually available and may be drawn upon—and probably will be drawn upon—in the preparation of the more comprehensive types of engineering reports and the more pretentious professional papers. The nature of this problem may be made clear by consideration of one type of problem that is common in professional engineering work.

A Typical Assignment.—A typical case is that of an engineer who has been retained by the board of aldermen of a city to report upon the adequacy of the city's sanitary sewer system and its accompanying disposal works. Such an assignment requires the collection of data with reference to three distinct phases of the problem. The first has to do with the present sewer system and disposal plant, including the amount and character of the waste and the degree of purification required. The second involves those studies necessary in order to forecast the requirements for the future, which involves a consideration of population trends, industrial conditions, the direction of the expansion of the city, and similar factors.

The third has to do with the financial condition of the city and the development of a sound financial program to take care of future expenditures.

In making a study of this sort the engineer might associate with himself various experts in particular phases of the sanitary engineering problem, including bacteriologists and chemists. A problem of this type touches many specialized fields such as those relating to the effect of sewage upon conduits made of various materials, the relation between the several kinds of industrial wastes, the efficiency of purification methods, the relative efficiencies of the types of mechanical equipment used in disposal plants, the load-supporting capacity of conduits laid at various depths, the hydraulic capacity of conduits of certain sizes on low gradients with effluents of a particular character, and many related problems.

It is doubtless apparent that, in preparing a report of the type that has just been mentioned, the engineer must assemble a considerable mass of technical data of one sort and another before he is prepared to answer the question that has been put to him. This is typical of many of the technical reports that are employed in engineering practice.

Sources of Report Data

A little consideration will reveal that there are really three sources upon which the engineer may draw for information pertinent to the solution of a particular technical problem:

1. Information the engineer already possesses, which may be in his files, in his notebooks, or in his mind.

2. Information possessed by other specialists in a particular field, which may be in their notebooks, in their files, or in their minds.
3. Information available in the published literature of the particular field.

In addition there will be required certain information that at the beginning is not possessed by anyone, but which must be obtained by the engineer through surveys, laboratory analyses, and studies of the features of the particular problem.

The foregoing classification of the data ordinarily needed for the preparation of an engineering report merely affords a convenient basis for the discussion of the steps involved in assembling the data necessary for the preparation of engineering reports.

Information Already Possessed by the Engineer.—

In each branch of engineering there are certain fundamental basic facts that are the working tools of that particular field of professional practice. The individual engineer acquires some of these facts during his formal education. Examples are: the laws of force and motion, the stress-strain relations existing in materials under load, the bacteriological basis for the purification of sewage, the laws relating to heat transfer, and many similar principles readily recognized by the trained engineer.

Additional facts will have been acquired by the engineer during the informal educational process that accompanies his professional activities. Among these may be such things as accepted methods of design of structures, costs of construction and operation of engineering facilities, sound methods of financing construction, available types of equipment, and similar

facts that are generally recognized as the outgrowth of practical experience. Some of this information will have been gained through the actual construction and operation of engineering works; some will have been obtained by visiting engineering works constructed by others and studying their design and operation; still other information will have been secured during his professional contacts, through attending various technical society meetings, the reading of technical literature, and the study of reports by other engineers. All of this information will be of such a character that it forms an invaluable background for the preparation of a report on a specific project. Nevertheless, there will be comparatively little of it that can be applied directly and unchanged to a specific problem. It must be assembled, weighed, and evaluated, and its relation to the project in hand determined upon the basis of the best judgment of the experienced engineer.

Information Possessed by Others.—Information possessed exclusively by other engineers is a part of their working capital and cannot be drawn upon without their consent. It has probably been obtained in their professional practice as outlined in the preceding section. They will be willing to make it available to other engineers upon the proper basis of compensation and should not be expected to make it available upon any other basis. Usually the most satisfactory arrangement in such cases is to bring in such an engineer as an associate on the project or to employ him as a consultant.

An exception to the foregoing may be mentioned. It has become the custom for the engineers in public

service to make available any information that they possess which may be useful to other engineers in coordinate branches of government service. Likewise it has been customary for the engineering organizations of the state and the federal government to make available to accredited public officials information that may be useful in handling public problems. That is, there is a general spirit of reciprocity in public service which may be of considerable value to the engineer if he does not abuse the opportunity. Whether such information will be made available to the engineer in private practice depends upon the circumstances. In many cases it will be made available but in others it will not.

In any case, where the engineer who is preparing a report on a specific project wishes to secure information possessed by other engineers, he should approach the question of securing such information with the recognition that it is a part of the equipment of some one else and he should not expect that it will be made available, except upon a suitable basis.

Information in Engineering Literature.—Very few problems that confront the engineer are entirely new. On the contrary, it is almost certain that a similar problem has arisen somewhere else, or at least there has arisen a problem involving many of the same factors. A survey of engineering literature should be one of the early steps in the preparation of an engineering report, and, no matter how complete the library of the individual engineer may be, it is impossible that he have available in his own office all of the publications that may carry articles relating to a particular problem. Libraries that carry a consider-

able volume of technical literature exist in almost every metropolitan center, and at many colleges and universities, and their resources are usually available to any inquirer.

The first step in a comprehensive study of the literature of the subject is the preparation of a *bibliography*, and this is most expeditiously done by consulting one of the standard indexes. There are two of these that are particularly useful to the engineer, "The Industrial Arts Index" and "The Engineering Index." These will be found in most libraries.

The mechanics of the preparation of a bibliography are rather simple. The indexes are consulted and any reference that appears to have a bearing on a particular problem is copied verbatim on a card that fits some standard file. This will require one or two lines along the upper edge of the card. After the possibilities of the index have been exhausted, or sufficient references have been obtained to give an adequate idea of what exists in the literature, each reference is examined and notes are made on the appropriate card as to the contents of the particular article, with notations of pages and tables that are later to be copied or photographed. If the articles that have been abstracted do not appear to cover the case entirely, additional researches in the indexes will follow until all of the possibilities have been exhausted. Many libraries provide facilities for having certain pages in the publications photostatted and others have provisions whereby the material may be typed at nominal cost. All of the pertinent material is gathered together in this manner and

transferred to the engineer's office for reference during the preparation of the report.

Most libraries furnish trained assistants who will aid the engineer in working up his bibliography. The reference librarians will prove to be exceedingly resourceful in locating material and in many libraries will prepare bibliographies at a nominal cost. The United Engineering Societies Library in New York City will at small cost prepare bibliographies that are exceedingly complete and exhaustive and will furnish at nominal cost photostat copies of material that is not available to the engineer in any other form.

Recently an instance came to the attention of the authors in which an engineer was in need of a particular type of dynamometer. After what he considered to be an exhaustive search of the literature, he came to the conclusion that none of the dynamometers described in the literature was suitable for the purpose of his problem and that it would be necessary to design one. However, he decided to make one more attempt to find additional information in the literature and finally discovered from an obscure publication that many years ago a dynamometer of exactly the type that he was seeking had been made and tested in a certain laboratory.

The report writer should be meticulous in giving credit in his report for material obtained from others and particularly that which is obtained from the literature on the subject. There are three aspects of this matter that may be considered.

1. Books, reports, and articles may have been read that aided in gaining a viewpoint and a basis for the

analysis of the project but from which no material was actually incorporated in the report. These may be listed in a bibliography as an appendix to the report. The list can be made up from the index cards filled out during the study of the literature of the subject.

2. The theory or method set forth in some publication may have been followed in certain parts of the report. That fact should be stated at the appropriate place and in a footnote on that page the exact reference should be given. The form of that reference may be that of the index reference, but in engineering reports another form is widely used, which is as follows:

Hatt, W. K., "The Effect of Moisture on Concrete," *Public Roads*, Vol. 6, No. 1, March, 1925, p. 14.

The "Industrial Arts Index" form of this reference is:

"Effect of moisture on concrete," W. K. Hatt, *Public Roads*, Vol. 6, No. 1, pp. 14-23, March, 1925.

Either may be used but the form adopted should be employed consistently throughout the report.

If a second reference is made on a page of manuscript or a printed page to the writings of an individual or a publication (with no intervening citation to some other publication), the repetition of the entire footnote may be avoided by the use of *loc. cit.* (*loco citato*, in the place cited), followed by the new page reference. Example:

¹ Mead, Daniel W., "The Flow of Streams and the Factors that Modify It," *Bull.* 425, Univ. of Wisconsin, 1910.

² *Loc. cit.*, Figs. 68 to 70, p. 308.

The terms *ibid.* and *op. cit.* are also used in footnotes according to a rather involved plan which is

hardly applicable to report writing and will not be discussed herein. The important consideration in engineering is to make the reference notes complete and to keep them on the same page as the citations.

3. It is sometimes desirable to quote material from a publication, in which case the quoted material will be typed so as to be set off prominently. If typed or printed indented, quotation marks need not be employed. In addition a footnote will be employed to give the source of the quotation, including the page on which the quoted material begins. The form of this footnote will be identical with the one employed for the references mentioned in paragraph 2, immediately above.

4. In certain types of research reports all references are listed in a bibliography at the end of the report and each item numbered. Reference in the text is by means of a number corresponding with the number of the reference in the bibliography. This method is almost never used for the professional report, as it is deemed more convenient to have the data as to the publication referred to shown on the same page as the citation.

Information Obtained by Field Examination.—Most of the problems discussed in formal reports are of such a character that some kind of field examination is required before the analysis of the problem is possible. The field data may sometimes be secured by a comparatively brief inspection, while in other cases complete engineering surveys will be required, and all grades in between will be encountered. The inventory necessary for the valuation of a public utility; investigations of the causes of failures of

structures; studies of power plants that are to be remodeled, sewer systems that are to be reconstructed, bridges that are to be strengthened, and buildings that are to be enlarged; all are examples.

In many cases tests of various kinds will be required, and these are likely to vary widely in scope. In the typical problem mentioned earlier in the chapter, an analysis of the sewage was required. If this analysis showed that the sewage was typical of that to be expected, the engineer would know that he was dealing with an effluent of a type that is regularly encountered and for which no special preparation or treatments would be required. If, however, the test showed elements present that would interfere with the usual type of treatment, it would be necessary to continue the laboratory studies until the proper method of treatment was discovered.

When it was decided to attempt a treatment of the sewage of the City of Milwaukee, an experimental plant was built and operated under actual purification conditions until the best method of treatment was discovered. The Sanitary District of Chicago has been conducting similar experiments for a number of years.

Consulting engineers ordinarily maintain staffs that are adequate to make the various kinds of studies that will be required in the solution of the problems that come to them. But an engineer may be called upon to make reports even though he does not maintain a complete staff. In such cases he must employ others to carry out some part of the laboratory or field studies. In such cases he will make use of results of tests made by others but must take the responsi-

bility for their accuracy and must accept the consequences should any error be made. Therefore he must outline the work to be done and at least in a general way supervise its progress. He must know that the data collected are correct and must see to it that they are properly recorded. Maps or plans that are necessary are completed as the field work progresses, so that discrepancies may be discovered and corrected while the survey party is available. In many cases the information obtained in this way is not included as a part of the report, but in some instances it must be included, ordinarily as one of the appendices. The assembling of this information is an important part of the preparation of a report, and the greatest care must be exercised to insure accuracy and completeness.

Methods of Obtaining Information from Other Persons

When satisfactory arrangements have been completed for procuring information possessed by others, some machinery must be set up whereby the desired information will be forthcoming.

Correspondence.—The simplest method, and the one most commonly employed when information is to be obtained from a single individual, is to write that individual a letter requesting the information. It will be furnished in the form of a letter report or a formal report, according to the requirements of the particular problem.

Interviews.—While a letter of inquiry is a simple and convenient method of requesting information,

it often happens that the results are not wholly satisfactory in involved problems. In such cases it is important to obtain the fullest information and, where geographical limitations do not prohibit doing so, the interview affords a means of securing information from others that has much to commend it.

When an appointment has been made to interview some one who can furnish needed information, the person who is to obtain that information should go into the interview only after careful preparation. In many instances the best preparation is to prepare a list of questions, and to propound these one by one and make notes of the replies that are received. This is perfectly feasible and satisfactory for certain types of interviews, especially those in which the request is being made for certain technical data.

When an interview gets into the question of an expression of opinion, particularly with reference to persons or types of equipment or patented processes, it is much better to ask the questions without reference to notes, and to take no notes as to the replies. As soon as the interview has been completed, however, copious notes should be made as to the statements that were obtained. In cases of this kind the person who is being interviewed is not likely to be as frank if he sees the interviewer making notes as he would be if no notes were taken in his presence.

The advantage of the interview lies in the fact that there can be complete discussion of each point that is raised, and a complete understanding reached between the two persons as regards the opinions of the person who is being interviewed. This is wholly impossible through correspondence in most cases.

Questionnaires.—The questionnaire method of studying technical subjects has been grossly abused for many years, and entirely too much dependence has been placed upon the information obtained through the use of questionnaires. It is presumptuous to ask another person to fill out a questionnaire unless there is some legitimate claim on his cooperation. The questionnaire should never be used by an engineer to secure technical (or other) information for his personal use. On the other hand, technical and professional societies, governmental bureaus, and educational institutions often participate in surveys of some phase of their group activities. Some of the data required in such surveys will most conveniently be obtained through the questionnaire and its use is justified by common consent of those who will have to fill out the document that comes to them.

Those who have had experience with questionnaires, or who have attempted to evaluate the replies received, realize the shortcomings of this type of investigation. The difficulties usually originate in the formulation of the questions themselves. If a question is to be answered properly, it must be so formulated that there can be no doubt as to the type of information it is desired to receive. In other words, an attempt should be made to formulate the questions in such a way that the meaning is unmistakable, and at the same time to make the question short enough so that it does not lead to impatience on the part of the person who is trying to answer it.

There are two types of questions that may be included in a questionnaire: the one that is a request for factual information, and the one that calls for

an expression of opinion. As the questionnaire is most frequently used, when legitimately used, it involves a series of questions calling for a reply in the form of statistical information. In questions of this type there is little difficulty in formulating a question in such a way that the desired answer will be forthcoming. Whenever possible it is profitable to formulate the question in such a way that it can be answered with a simple "yes" or "no" or by the insertion of a numerical quantity. Questionnaires of this type are usually handled rather carefully and expeditiously, if the claim for the information is legitimate.

The "yes" or "no" types of questions may be designed to elicit facts or they may invite an expression of opinion.

The following questions appeared in a questionnaire on the subject of railway-track maintenance. Questions 1 and 2 are of the "yes" and "no" type but the first seeks facts while the second elicits an opinion.

1. Does your road practice building up battered rail joints by welding?
2. Do you think the results justify the cost?
3. How many miles of track have been so repaired?

To answer questions like the first and second requires little time and the replies will generally be dependable. Questions requiring a numerical answer like the third sometimes necessitate considerable work and as a result the data, if given at all, will often be no more than a guess.

Individual questions obviously should not contain requests for two kinds of information. In a questionnaire on levee construction, the following question was asked: "What bank materials are most desirable

and what the least?" In order to answer such a question, it is necessary to write a long discussion, a thing not desirable in a questionnaire. It would have been much better to have asked two questions, one requesting information regarding the material thought to be most desirable and the other the material thought to be the least desirable.

Where the question cannot be answered by "yes" or "no," it should be so designed that the answers received will be comparable. In the questionnaire mentioned in the preceding paragraph the question "What determines the height of the levee?" was asked. Out of some twenty replies only two gave the high-water stage of the river as the determining factor, although this is probably one of the most important. Since there are evidently a number of factors governing the height, the information would have been of much more value if it had taken the following form.

Rate the weight to be given the following factors in deciding upon the height of a levee.

Height of flood stage of river_____

Character of material in embankment_____

Economic benefits_____

Ability to finance_____

The make-up of the questionnaire has considerable influence on the number of replies which will be received. The U. S. Department of Agriculture is continually sending out inquiries regarding stock and crop production and they find that questionnaires containing only six or seven questions receive the

most attention and their feeling is that more than ten should not be used. Inquiries printed or typed on light colored paper bring a larger number of replies than those printed on dark paper.

In addition to these features there are a number of other details which are important.

1. The sheet on which the questionnaire appears should be of a size that fits a standard file and the paper of such quality that it will take ink readily.

2. The questionnaire should be printed rather than mimeographed. Multigraphed questionnaires may be used if the printing is clear.

3. Identification data on the person to whom the inquiry is sent should be entered in the questionnaire before it is mailed. Include the name, address, and position or title of the person and the name of the organization with which he is connected.

4. If inquiries are sent to more than one class of persons, mechanical engineers and electrical engineers, for example, the blank form for each class may be printed on paper of a distinctive color so that the answers may be more readily segregated.

5. Each questionnaire should be accompanied by a letter which explains why the information is being collected. This letter is an attempt to sell the idea of the questionnaire to the person to whom it is sent so that he will feel that the demand on his time is justified and that by filling out the blank he is rendering valuable assistance to a cause in which he is really interested. It is a courtesy that is sometimes appreciated to offer to send to each person who accomplishes the questionnaire a résumé of the results if he desires it.

After every effort is made to design the questionnaire so that the work required is reduced to a minimum, the percentage of those sent out that will be returned will be small. Among those returned will be a number which are biased and ought to be discarded if they can be detected. When care is exercised in the selection of the persons to whom the questionnaire is sent, the returns will be worth something. But avoid the use of the questionnaire as one would the plague if it is to be sent to a miscellaneous group of people upon whom the sender has no legitimate claim. The results will usually be of no value whatever.

Office Work on Report Data

This chapter has dealt with some of the methods that are employed in securing factual material for engineering reports. The precise office procedure followed in gathering the material together so it can be examined and studied will vary greatly. Some really systematic scheme is usually adopted but there is no particular "one best" way to take care of the mechanics of getting the data together for examination.

CHAPTER VI

STYLE AND ARRANGEMENT

When the engineer has gone to great lengths to produce a report that he believes to be valuable, he would like to feel that some one will read it in its entirety. If he takes some thought as to the prospective reader and tries to write in a manner suitable to the reader's mentality and education, it will do a great deal to insure that the report will actually be read. This should be so clearly apparent that it would require no elaboration. Of what value is a report if the one who receives it is unable to understand it because of the specialized vocabulary or complicated graphs and diagrams? Of course, some qualified person could be called upon to interpret it, but that defeats its very purpose, although it might in some cases be necessary for some parts of the work. Even when striving to write in a vein that is understandable to the reader, the engineer may inadvertently use some terms or expressions that are not clear to a non-technical reader but as a whole his work should be couched in language understandable by those who are expected to read the report.

Clearness.—Adapting the report to the technical limitations of the prospective reader is only part of the task, however. The other part is to write in such a manner that the meaning is unmistakable. This statement should need no amplification because so often the safety of human beings and the integrity

of investments depend upon engineers' reports and, therefore, possible misunderstanding should be sedulously provided against. This is primarily a matter of the use of words according to the exact dictionary or technical usage, with due consideration of fine shades of difference in meaning.

Style.—The report should be in a style that is not only readable but also interesting. So many really valuable technical reports fail to reach their highest usefulness because the style is such that it is very difficult to follow the discussion and only those most interested will have the time to excavate the gems of scientific discovery or the fruits of painstaking analysis from the debris of aimless description and argument.

Vocabulary.—Adapting the phraseology to the prospective reader has already been mentioned. The general principles involved are simple. An electrical engineer is just as familiar with the terms employed in the basic sciences of physics, mathematics, chemistry, and mechanics as the civil engineer and any reference to these subjects by either would be understood by the other. The mathematician might write on a subject in his field which would be outside the ordinary training of the engineer, who would be unable to understand the terminology until he had done considerable collateral reading and study. This he would not do unless the report were a very valuable addition to the theory relating to some phase of the work upon which he was engaged.

Each division of engineering has its own vocabulary to a certain extent, but there is no necessity for using that vocabulary for reports that may be read by

engineers who practice in other branches of the profession. The general rules with reference to phraseology may be stated somewhat as follows:

1. In reports prepared primarily for other engineers in the same branch of the profession, use the vocabulary current in that branch of engineering without special explanation. This is the simplest way of saying what is intended and is good form and perfectly understandable to the prospective reader.

2. In reports that may be read by engineers in any branch of the profession, use any terms current in all branches of the profession, but avoid those terms peculiar to a single branch unless there is no convenient substitute. If special terms must be employed, they should be defined when they are first introduced.

3. Reports intended for non-technical readers should be written in non-technical language so far as possible, and the engineering implications of the salient facts in the report should be explained with great care.

Many instances arise in which it is desirable to write a report that is suited to all classes of readers, and to do this it is necessary to adopt the non-technical vocabulary, as a matter of course. The purpose of the report may be to give general publicity to some engineering project and then the engineer will not only employ the ordinary language of the layman but also strive to secure the attention of his prospective readers by carefully planned comparisons and illustrations that are readily understood by the casual reader. He will also exert every effort to make the description vivid and the whole report interesting as well as instructive.

Reader Interest.—The report writer strives to carry his reader along as the argument and discussion proceed so that things or ideas will seem real and tangible. Several devices of style are available for the accomplishment of this purpose and the one selected will depend upon the nature of the report.

One of the methods of holding the reader's interest and making it easy for him to follow the trend of the discussion is to employ a time sequence in writing the report. To do so, the several elements of an operation are discussed in the order in which they are performed. As an example of this method, a report on the methods followed in assembling a motor car would take up the several operations in the assembly line of the plant in the order in which they are performed. A similar method might be followed in a report on the fabrication of the steel for a bridge, the erection of a structure, or the operation of an automatic machine. It will be apparent there are many kinds of reports that lend themselves to this method.

Some reports deal with subjects of such a nature that it is desirable to use a space or geographical sequence. That is, the several elements of the plant or structure with which the report deals are discussed in the order in which they are examined. Thus in a report on the condition of a highway, the engineer might describe the condition of successive lengths in the order in which he examined them. This method is effective in reports on sites for industrial plants, on the condition of sewage-treatment plants, on the arrangement of the interiors of buildings, and similar subjects.

The report may follow a logical sequence whereby the several elements are discussed in the order of their seeming importance. In a report dealing with a proposed water-power installation, the author would discuss the various factors in the order best calculated to impress those for whom the report was prepared. This arrangement is particularly well adapted to reports preliminary to construction and on projects in the formative stage. It is also applicable to reports on failures.

A report may follow the order in which the various divisions of the subject were studied but this is, perhaps, the least effective method. The engineer must arrange his investigations in such a way as to conserve time and consequently may not follow a logical order. In presenting the report he can rearrange his material so as to secure an effective sequence.

Transition Phrases.—As the report develops, the writer presents a series of ideas, related facts, and deductions, but if he passes abruptly from one to the next the connecting thought may not readily be perceived. A transition paragraph following each part will serve to lead the reader's thoughts from the idea just presented to the one about to be introduced. The reader is probably unfamiliar with many of the facts and relations known to the writer, and that requires the inclusion of certain explanatory material that is quite elementary to the engineer who is preparing the report.

Illustrations.—The reader's interest and comprehension of a report can be aided very greatly by the use of appropriate charts and diagrams. The pos-

sibilities in this direction are so great that a section of this treatise is devoted to the subject.

Good English.—The clearness of a report is enhanced to no small extent by the correct use of words and accurate sentence construction. The engineer is prone to use words in an inaccurate way or to overwork certain words or expressions. Repeated use of the same word results in a monotony of style that is deadening, and the inaccurate use of words contributes to ambiguity. Sentences should not be too long and not too short, but it is better to err on the side of brevity. Long sentences are likely to lack clearness or to be awkward in construction.

Accuracy in the use of words and a careful selection of the best word to denote the desired shade of meaning contribute to clearness and a vivid style.

Editing.—After a report has been formulated and the rough draft prepared, the work of editing begins. After the first painstaking revision, lay the report aside for a day and then revise again. If possible to secure the time, revise a third time. A well-known editor states in his memoirs that he found it profitable to revise his work no less than six times and yet his first draft would doubtless be considered excellent writing by many authors.

Mechanics of Arrangement.—It should be the aim of the engineer to arrange his report in an attractive form so that the first impression upon the reader is a favorable one. Genius can afford to dress in a slovenly manner (but seldom does) and the engineer of long-established reputation knows that his work will be accepted regardless of form. However, it is

doubtful if he would have gained recognition had he, in his earlier work, disregarded the value of appearance. The outstanding expert generally does not countenance anything but the most exacting care in the presentation of his reports.

An examination of the papers in the *Transactions* of the American Society of Mechanical Engineers or the publications of any society of a similar character will show that very great pains are taken to present subject matter in a precise but attractive form. Not only is the style employed for references, abbreviations, and phraseology carefully standardized but also the arrangement, draftsmanship, and typographical features.

Since good reports exemplify so fully the value of care in these details, it should be obvious to the young engineer that he must not neglect them. It should be his constant purpose to have each report so nicely arranged that it will attract attention immediately upon its receipt. Of course, the report itself must deal adequately with the subject and show that the writer has analytical ability and an appreciation of his problem, if the first favorable impression is to be sustained. One would scarcely expect to gain a sympathetic hearing when applying for a position if he presented himself in ill-kept clothing and soiled linen, nor should he expect a haphazard-looking report to be received with any great enthusiasm.

The correct arrangement is important from the standpoint of the facility with which the report can be examined. The busy engineer wishes to learn the contents of the report in the very shortest possible time. An arrangement of subject matter that is

intended to aid in so doing has already been described, but the mechanical make-up should be such as will accentuate the several elements of the report, each part being clearly set off so that it can readily be found.

Arrangement is largely a matter of symmetry and design: symmetry in order to get a pleasing appearance, and design to insure ready reference. Likewise, the selection of typographical style is a matter of design. By the exercise of a little ingenuity a pleasing arrangement of type can be perfected for the typewritten report and, of course, the printed report offers a wide choice of type sizes and styles.

The main body of the report is broken up into sections, each indicated by an appropriate heading set in the middle of the line across the page, often with a section number or letter as follows:

SECTION 2—DATA TO BE OBTAINED

I. The Problem Outline

A. History of the Case

In general, each section corresponds with one of the major subdivisions of the body of the report as outlined in a previous chapter. The main body of the report is indicated by a title which is an abbreviation of that used in the title page. The divisions of sections are indicated by paragraph headings set in distinctive type and indented. These subdivisions may consist of many paragraphs each, but no special designation is given to any but the opening paragraph.

The appendices are usually designated by an independent series of letters or numbers and each is

paged separately from the main report and other appendices.

Tables in the main report are numbered consecutively, roman numerals being used if there are not too many tables. But if the number exceeds twenty, it seems simpler to use arabic numerals. The tables in each appendix are numbered consecutively through that appendix.

Graphs and diagrams are usually designated as "figures" and are numbered consecutively through the report. Figures in the appendices are numbered consecutively through each appendix.

Outlines.—Perhaps there are rare individuals who can visualize a completed report with sufficient clarity that they require no written outline. That is, they really follow a clear mental outline. But to the great majority of engineers and especially the younger men in the profession, a written outline is indispensable. It not only insures the inclusion of every item in its proper place but also conserves time in the writing, since the framework is provided by the outline, and repetitions and omissions are not as likely to occur as would be the case if no outline were used.

In the preparation of outlines several forms may be employed, and there is perhaps little reason to argue in favor of any particular one. A system that is quite satisfactory is as follows:

Indicate the main divisions of the report by roman numerals, the main subdivisions by capital letters, the secondary subdivisions by arabic numbers, and the sections by lower-case letters, thus:

V. Text of Report**A. Occasion for the report**

1. Request for data
 - (a) from public service corporations
 - (b) from commissioners
2. General need for the information
 - (a)
 - (b)
 - (c)

etc.

B.

1.
 - (a)
 - (b)
 - (c)

etc.
2.
 - (a)
 - (b)
 - (c)

etc.

Essential Characteristics of a Good Report.—An engineer's report may be technically sound and contain valuable information and yet not be a good report. It is conceived that a good report is one that complies with each of five specifications with respect to details of materials and arrangement.

1. The arrangement, phraseology, and illustrations must be such as to enable the reader to get readily at the meat of the report.

2. The material in the report must be of such a character as to carry conviction. The conclusions are not to be accepted primarily because they are presumably the opinions of the writer, but rather because the data presented lead inevitably to the conclusions stated.

3. The whole report must be sufficiently complete and detailed to permit an independent check of the work by any other engineer who is reasonably familiar with the field of the report. It is seldom that reports on important projects escape close scrutiny from other engineers, and often they are subjected to unfriendly scrutiny. But if the requirements of paragraph 2 above have been met and the material is susceptible of being checked, there need be no concern as to the fate of the report.

4. The really good report has literary merit. That does not mean that the engineer should use a great many long words and ponderous statements. Rather the reverse is true. The style is terse and impersonal, but the statements are clear and unequivocal. The grammar is correct and words are used with exactness rather than in accordance with the careless habits of speech that are not uncommon. Repetition of pet words must be avoided. Punctuation and sentence structure should be accurate and suited to the purpose. In short, the report should be easily read, each idea being connected to the foregoing by suitable phrases.

5. The typographical arrangement should be carefully planned so as to assist the reader in following the argument of the report. There is less variety in type styles available when the report is typewritten than when printed, but some variety may be obtained even in a typed report. The following styles are generally assumed to be equivalent:

PRINTED

TYPED

12-POINT BLACK - WRITTEN IN THIS MANNER
FACE CAPITALS

10-POINT BLACK - WRITTEN IN THIS MANNER
FACE CAPITALS

10-point caps and low- Written in This Manner
er case black face

10-point caps and low- Written in This Manner
er case

The typographical variety that can be secured in typed reports is indicated by the reproduction on page 97 of a page of a typed material.

SECTION IV
STYLE OF TYPING

This page illustrates the typography that may be secured in typed reports and indicates that considerable variety and a pleasing appearance can be obtained by the following devices:

1. Breaking up the text into sections and paragraphs with suitable headings.
 - (a) Running text is usually double spaced.
 - (b) Quoted material and material included for reference may be single spaced.
2. Utilizing capitals, captions, and underscoring to give emphasis to the divisions of text.

Typography Is a Problem in Design

The problem of typography for typed reports involves designing a page that will have a pleasing appearance, with important elements duly emphasized by the arrangement and type style.

Tabular Matter.—Tables are extensively used in reports and the typing may be as in the following example:

Table I.—Illustrating Arrangement of Column Headings

Group No.	Heights of fill, feet	Gross load, pounds	Weight on rear wheels, pounds	Weight on front wheels, pounds
I	2, 3, 4	16 180	11 400	4 780

Quoted Text.—Quoted material may be run as the balance of the text and enclosed in quotation marks or it may be indented and single spaced as follows:

No full-blooded engineer could read of the Normandie and Queen Mary, the two greatest liners afloat, without a thrill of pride in his profession.¹

¹ "It would take more than a depression to stop engineering development," Machine Design, Vol. 7, No. 6, p. 40, June, 1935,

CHAPTER VII

DIAGRAMS, CHARTS, AND GRAPHS

In preparing the manuscript for a report of any magnitude, the engineer is confronted with the problem of presenting a considerable mass of technical data of one sort and another in such form that it can readily be checked, analyzed, or otherwise studied by persons who may, at the beginning, be entirely unfamiliar with the project covered by the report.

The extent to which detailed numerical data will be included in any report depends somewhat upon the particular purpose of the report and the nature of the material to be presented, but, in the main, sufficient numerical data should be presented to permit a check of the accuracy of the conclusions, and to form a permanent record of the basic facts that were assembled during the study of the problem. It is entirely appropriate, however, that survey data be presented in the form of maps, and that detailed computations of stress and other factors involved in design may be omitted, provided there are stress sheets and tabular summaries to show the final figures reached.

Numerical data are usually given in tabular form and in addition many of them will also be shown in graphs and diagrams arranged to bring out the significant facts and comparisons with sufficient clearness

that little study is required by the reader who wishes to familiarize himself with the trend of the results. The more common forms of tabulations, diagrams, and graphs will be discussed in the following sections.

Tabulation.—The most common form for recording engineering data is the tabulation, which is a convenient method of giving a large amount of exact information in comparatively small space. Tabulations, however, are not readily understood by the layman, nor do they in general yield valuable results without a certain amount of detailed study. The tabulation should be looked upon as a method of presenting for preservation the data that should be included in the report, and not as a method of presentation that is particularly impressive or convenient to the person who studies the report more or less casually.

The form employed for tabulating data is so common and so well understood that it requires only a brief mention herein. The orthodox tabulation consists of a left-hand column of figures which are generally, although not always, related to each other, but which are selected by the tabulator with a view to bringing out the facts he wishes to establish. For example, the column may consist of a time series such as a succession of years or months or days or hours of the day. It may consist of sums of money arranged in series or other arithmetical series. It may even consist of quantities which are not directly related to each other, as, for example, colors or names of articles or of people.

In the simplest form of tabulation there are but two columns. The first is of the character just

described, and the second gives some quantity which is dependent upon the corresponding figure in the first column. For example, if the first column were years, the second column might be mean temperatures or mean rainfall or the number of deaths from some particular disease. That is, the first column is made up of independent variables while the second column is made up of dependent variables. A third column may be added in which certain data are given that depend upon the quantity in the second column and are directly related to the first column. This is illustrated by the following simple tabulation showing a historical time series, giving the consumption and the cost of coal burned in a power plant over a period of several years. An arrangement of this type is usually referred to as a "single tabulation."

TABLE I.—COAL CONSUMPTION

Year	Tons	Cost
1923	13,250	\$53,000
1924	14,220	56,880
1925	14,650	58,600
1926	16,275	64,100

From this single tabulation, which is so commonly used and readily understood, we pass to the more complex forms of tabulation. In these more elaborate tabulations the first column, as in the case of a single tabulation, is an independent variable, while the succeeding columns are made up of quantities related directly to what is given in the left-hand column, and in many cases one of these is derived from the other.

For example, in a double tabulation a single question is answered, but that answer is divided into several of its component parts. This is illustrated by the following tabulation which shows the cost of boiler-plant operation.

TABLE II.—COST OF BOILER-PLANT OPERATION

Year	Water	Coal	Labor	Miscellaneous	Total
1923	\$4,250.00	\$55,000	\$15,000	\$3,400	\$77,650
1924	4,375.00	56,880	15,200	3,55	80,005
1925	4,490.00	58,600	15,410	3,670	82,170
1926	4,510.00	64,100	15,350	3,650	87,610

The tabulation may be still further expanded by dividing the answer to the question into several component parts, with a total for each year, as is illustrated in Table III which shows the cost of boiler-plant operation, divided into the cost of each of a number of the constituent items. This is sometimes referred to as a "triple tabulation."

TABLE III.—COST OF POWER-PLANT OPERATION

Year	Boiler plant				Turbine plant				Total cost
	Labor	Supplies	Misc.	Total	Labor	Supplies	Misc.	Total	
1923	\$15,000	\$57,250	\$3,500	\$75,750	\$5,800	\$1,650	\$975	\$8,425	\$84,175
1924	15,200	61,225	3,550	79,975	5,750	1,760	990	8,500	88,475
1925	16,410	63,090	3,670	82,170	5,820	1,700	985	8,505	90,675
1926	15,350	69,610	3,650	88,610	5,900	1,690	925	8,515	97,125

A form of tabulation shown in Table IV might be designated as "multiple tabulation." It will be noted that, as in all other forms, the left-hand column is a series of independent variables. The material in the succeeding columns is related to the material in the left-hand column but is tabulated from records or derived from the tabulated material by various computations, which are indicated in the column headings. A tabulation of this sort is exceedingly useful in presenting the results of an elaborate series of computations in such a form that the material is given in comparatively small space in a report, and yet in such form that one familiar with the general problem would be able to check from one column to the next.

TABLE IV.—OPERATING PERFORMANCE OF A TURBINE

Year	Months	Net mega- watt- hours	1,000 pounds of coal burned	Avg. net genera- tion, mega- watts	Net station capacity factor	Number of starts	Net turbine water rate
1930	2½	44,505	48,389	23.8	29.7	...	11.09
1931	12	94,934	136,302	13.2	8.3	114	11.30
1932	12	80,069	130,291	9.1	5.7	71	13.00
1933	First 5	29,976	50,031	8.2	5.1	6	13.38
1933	Last 7	330,890	346,708	64.5	40.3	97	10.65
1933	12	360,866	396,739	41.2	25.8	103	10.88
1934	12	314,667	345,527	35.9	22.5	125	10.88

Graphs and Curves.—Graphs and curves are used to present data in such form that the trend and magnitude of the data are quickly visualized. In addition, curves are frequently employed for calculations to be made by graphical methods.

The most common form of graph found in engineering literature is the curve drawn to coordinates which represent numerical quantities according to some convenient scale. The graph drawn to rectangular coordinates is probably the most widely used of any, although some graphs are drawn to other types of coordinates, either oblique or curvilinear. This form of presentation is so widely used that it requires little discussion beyond the mention of a few basic characteristics of such presentations.

It is the custom to draw the graph to coordinates which are so arranged that the ordinates represent values of the independent variable and the abscissae values of the dependent variables. The individual values of the quantity represented may or may not be such that a smooth curve can be drawn through them. Ordinarily the points representing the data will be shown and will be connected with straight lines, although the quantity may not vary between those points exactly as a straight line. It is assumed, however, that observations are sufficiently close together that no significant error will result from assuming a straight-line variation between points. For many purposes it is convenient and adds to the value of the presentation if a smooth curve is drawn to fit the points as nearly as that is possible instead of actually connecting up the points.

It goes without saying that the title to the graph should show clearly what is represented, that the scales be plainly marked, and that, if more than one curve is shown on a sheet, each curve should be clearly identified. Likewise, the points on the curve sheet representing the values of the data that are the basis

of the curve should be indicated by a code that will make it possible to determine clearly which points apply to each curve. For example, solid dots may be used for one curve, small circles for another, triangles for another, small crosses for another, etc. It is not desirable to place too many curves on one sheet, especially if the data causes the curves to cross and

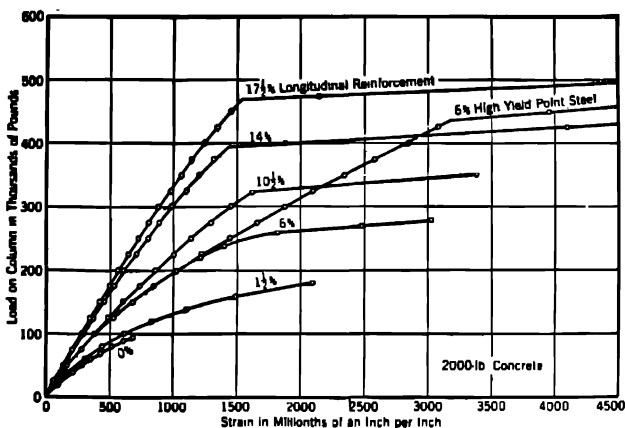


FIG. 6.—Load-deformation diagrams showing that there is a limit to the number of curves that should appear on one diagram. (*Civil Engineering*, p. 366, July, 1933.)

recross each other. In such cases probably the limit would be about five curves on one sheet.

From the typographical standpoint it is desirable that the lines of the coordinate paper upon which the curves are drawn be inked rather lightly, with those representing basic units, such as 1, 2, 3, or multiples thereof, being more heavily drawn than those representing decimal parts of the basic units such as five-tenths or one-tenth. The curves themselves should

be shown by means of lines that are more heavily inked than any other feature of the sheet. A typical curve sheet is shown in Fig. 6.

Graphs such as those just described are convenient for showing the relative magnitudes of quantities involving two variables, but it sometimes becomes desirable to show the variation in quantities involving three variables, in which case a curve sheet may be prepared in the form of an equilateral triangle and magnitudes of each of the three variables shown along each of the three base lines of the coordinate sheets. Such a diagram is known as a "trilinear coordinate sheet."

Another form of diagram that may be employed to represent data involving three variables is called the "hodograph" and a typical example is given in Fig. 7. The method of construction is readily apparent.

In some cases values for the independent variable are shown on the y -axis, values for one of the dependent variables on the y' -axis, and values for the second dependent variable are shown on a curve intermediate between the y - and y' -axes, the form of this curve depending upon the relationship between the quantities.

Alignment charts for four variables are also extensively employed in the presentation of report data. These take many forms, but a type in which logarithmic plotting is employed is shown in Fig. 8.

The diagrams considered in the foregoing sections may be plotted with the coordinates shown arithmetically, or the coordinates may be shown to the logarithmic scale. A brief mention of some of the characteristics of diagrams drawn to a logarithmic

WEGMANN-AERYNS FORMULA

$$V = 182.5 R^{0.723} S^{0.539}$$

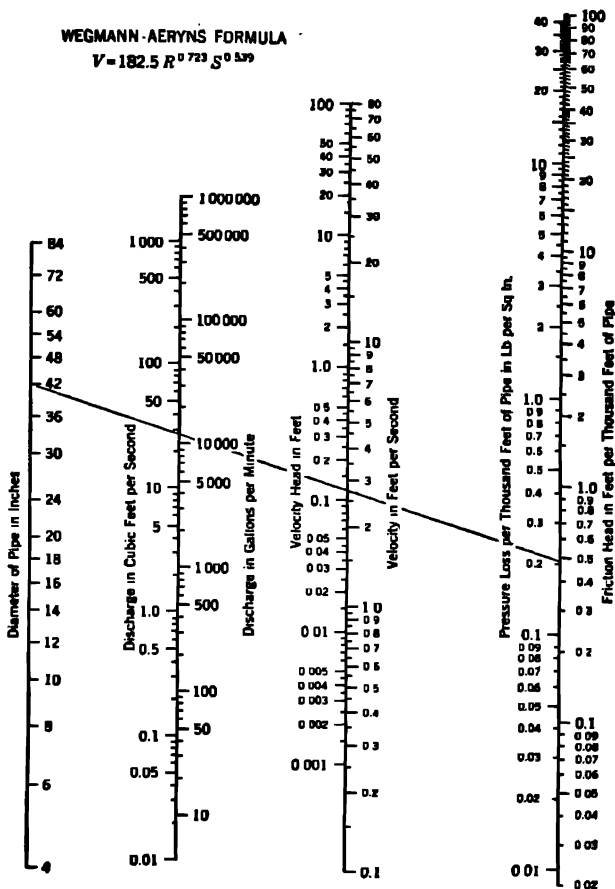


FIG. 7.—Type of hodograph frequently used to show the relationship between the magnitudes of three or more quantities. (*Civil Engineering*, p. 601, November, 1934.)

scale will perhaps aid in indicating when this type of diagram should be employed. If a second-degree

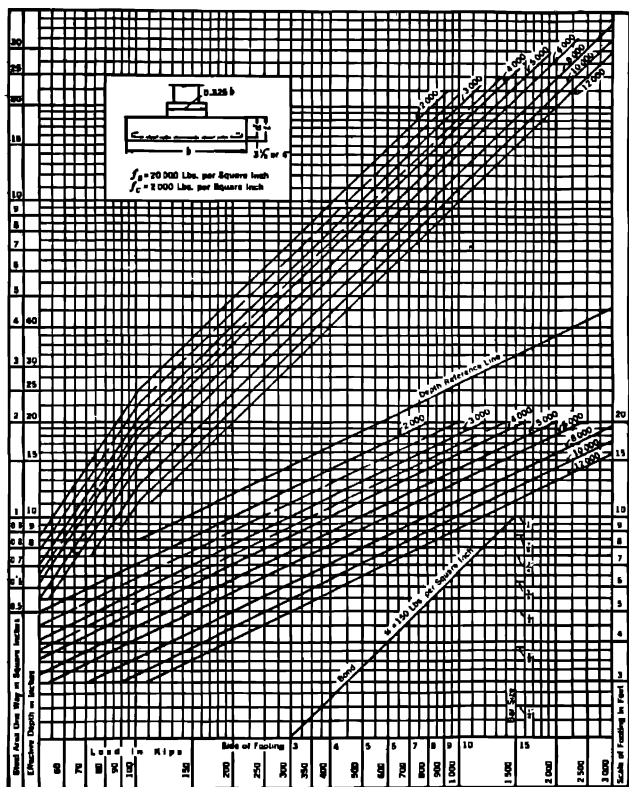


FIG. 8.—Alignment chart to a logarithmic scale to be used in the design of footings. (*Civil Engineering*, Vol. 2, No. 10, p. 649, October, 1932.)

curve is plotted to logarithmic coordinates, it will appear as a straight line. A curve of any other type may also appear as a curve when plotted to the loga-

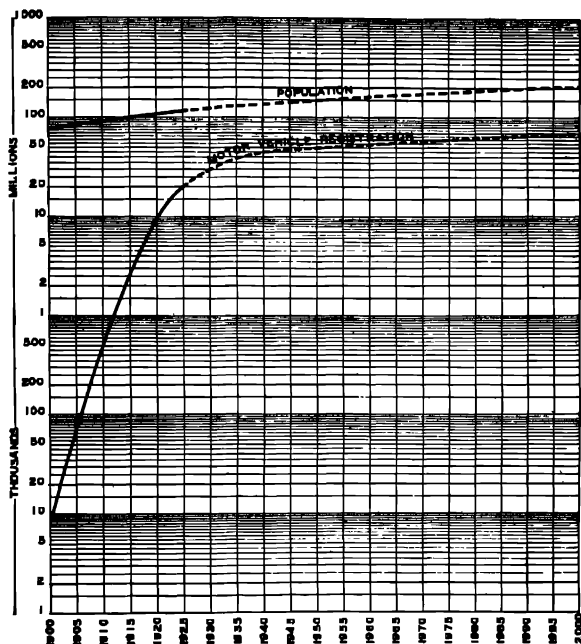
rithmic scale, but the degree of curvature will be less than if the curve were plotted on the ordinary arithmetical coordinate paper. It is convenient to use a logarithmic paper when the data runs into curves that are so sharp that the intercepts are difficult to determine with accuracy, and consequently small differences in values do not show up very clearly in the diagrams. Logarithmic plotting is also employed when it is desired to find the mathematical form of the curves but that problem is not considered herein.

Logarithmic coordinate paper may be purchased from the supply dealers, but if the engineer does not have it available he can readily prepare his own logarithmic paper. The process is to plot on ordinary rectangular coordinate paper the logarithms of numbers 1 to 10, then erase or disregard the rectangular coordinates and plot the data to the logarithmic scale that has thus been prepared.

In many instances it will be found convenient to use what is known as "semi-logarithmic" paper for the presentation of certain forms of data. This paper is prepared in such a way that the ordinates are laid off to a logarithmic scale, and the abscissae are laid off to the arithmetic scale. Semi-logarithmic plotting is shown in Fig. 9.

If the mathematical form taken by the data in any particular instance happens to be known, the choice of the type of coordinate paper to use for the presentation could be made without further consideration. However, the data encountered in report work will not ordinarily be in such a form that the mathematical type of curve is readily determined, and consequently some experimenting may be required to

determine which is the most satisfactory form of data sheet to employ in the presentation of the curves.



RELATION OF MOTOR VEHICLE REGISTRATION TO POPULATION IN UNITED STATES

1900-1925-UNITED STATES CENSUS AND GOVERNMENT REPORTS
1925-2000-FORECAST

RAPID TRANSIT COMMISSION-DETROIT
OCTOBER 1927

FIG. 9.—Showing use of semi-logarithmic scale in a graph comparing motor-vehicle registration with population.

Bar Diagrams.—Bar diagrams consist of horizontal or vertical lines, the lengths of which represent the

magnitude of some particular quantity and the position of the line in a diagram, or the number or key to the bar represents the quantity pictured. These diagrams are very useful in presenting certain kinds of data which are not directly related to each other and cannot, therefore, be represented by curves. For example, if it were desired to picture the relative populations of a number of cities, the simplest method would be to draw vertical bars to a length representing the population and to show the name of the city, either on the bar or at one end of it. The amount of water required per capita in a group of cities might be shown in this way, or the number of miles of each type of road surface upon a state highway system could be conveniently represented by a bar diagram. Figure 10 is a typical bar diagram.

Pictorial Charts.—Sometimes it is desired to represent graphically the variation in a given quantity over a period of years, such, for example, as the increase in automobile registration in a given area. This might be accomplished by a curve or, if a graphical representation is desired, by allowing one automobile to represent the registration in the base year, and multiples of that number to represent the registration in succeeding years. Many reports prepared for non-technical readers show this variation by an automobile of a certain size for the base year and by automobiles of another size each succeeding year. Such diagrams do not really present the picture since the eye cannot compare areas as readily as it can linear quantities. For example, a single freight car has been used to represent the car loadings in a certain year, and another car of a different size to

represent the loadings in another year. It is difficult for the reader to sense the differences in magnitude

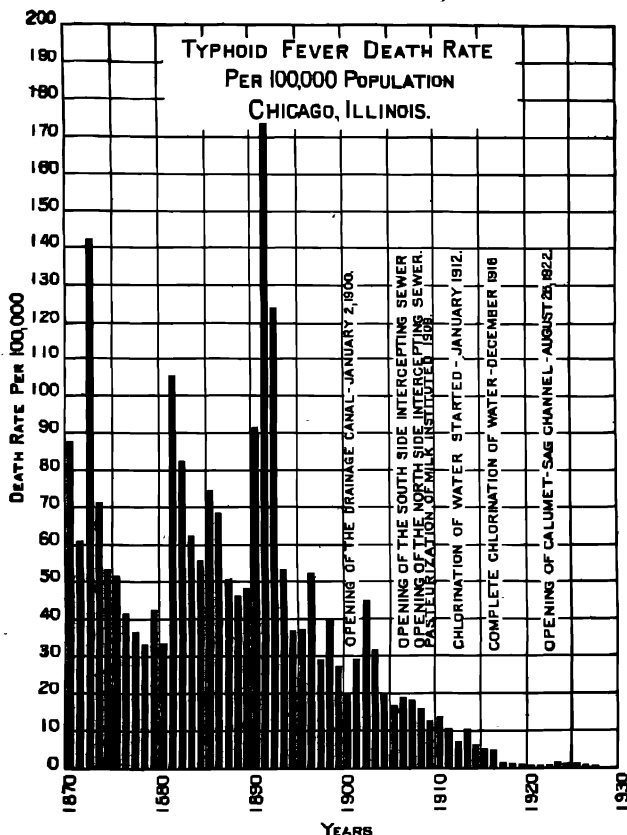


FIG. 10.—Typical use of the bar diagram.

of the corresponding areas. It would be better to show a single car to represent the base year, and one

or more cars of the same size to represent the loadings during other years.

Maps and Plats.—The use of maps and plats is so common in engineering work that their application to report writing needs no particular discussion beyond the caution that a map or plat should not contain too many kinds of data. A plat might be prepared for the catchment area adjacent to a water-supply reservoir, upon which was shown the ownership of several tracts of land, the character of the soil, the topography, and all other factors involved in the problem, and such a map will be entirely satisfactory for study by engineers. If, however, the map were to be used in connection with general publicity on the project, it would be better to separate the data into several parts, showing on one map the ownership of the land, on another the types of soil, and perhaps on a third some suggestion as to the topography. (See Fig. 11 for a type of plat used in report work.)

Flow Sheets and Organization Diagrams.—The engineer has adopted a type of diagram known as the "flow sheet" for showing the organization of the equipment and the sequence of processes in manufacturing enterprises. There is no fixed form for the flow sheet, but the one most commonly employed indicates each piece of apparatus involved in the process diagrammatically with lines and arrows indicating the flow of materials through the process. In many diagrams of this type the major apparatus is represented by a drawing whose shape indicates the general nature of the apparatus. For example, a tank will be represented by a circle, a motor with the outlines of the motor itself, and various kinds of

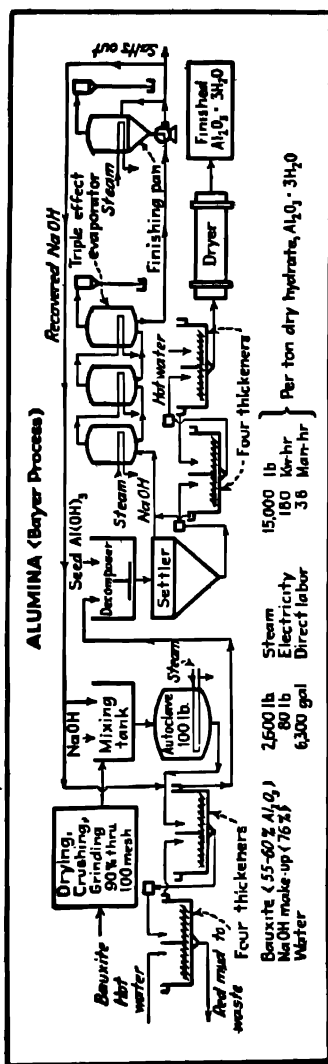


Fig. 12.—Typical flow diagram employed in reports on chemical processes. (*Editorial Supplement to Chemical and Metallurgical Engineering*, Vol. 41, No. 5, May, 1934.)

special apparatus, such as filters, refiners, dryers, and the like, are represented by shapes roughly approximating those of the apparatus indicated. In other forms of flow sheets no diagrammatic representation of the several pieces of apparatus will be shown, but instead the apparatus will be indicated by title and a brief description, and each of the pieces of equipment then connected by lines with arrowheads showing the flow of materials in the process. Figure 12 is a flow sheet of a type used in chemical engineering reports.

Organization diagrams are employed to indicate the relative responsibility of the personnel in a factory or construction or administrative organization. These are quite simple and the general arrangement and principles of presentation are clearly indicated by the example given in Fig. 13.

The circular chart, more popularly known as the "pie diagram," is a convenient method of representing pictorially the distribution and magnitude of the several parts that comprise a quantity. For example, the cost of operation of a factory may be represented by a circular area which is divided into slices, each indicating the portion of the total cost incurred for various items, such as labor, supplies, management, depreciation, and the like.

Other types of graphs and diagrams commonly employed in engineering reports are shown in Figs. 14 to 20.

Photographs.—Photographs constitute an important means of recording conditions that exist in a structure or site upon which a report is being prepared. Also photographs may give very deceptive impres-

sions if they are not properly posed. Reproductions from photographs may be used advantageously for many types of reports and for the presentation of

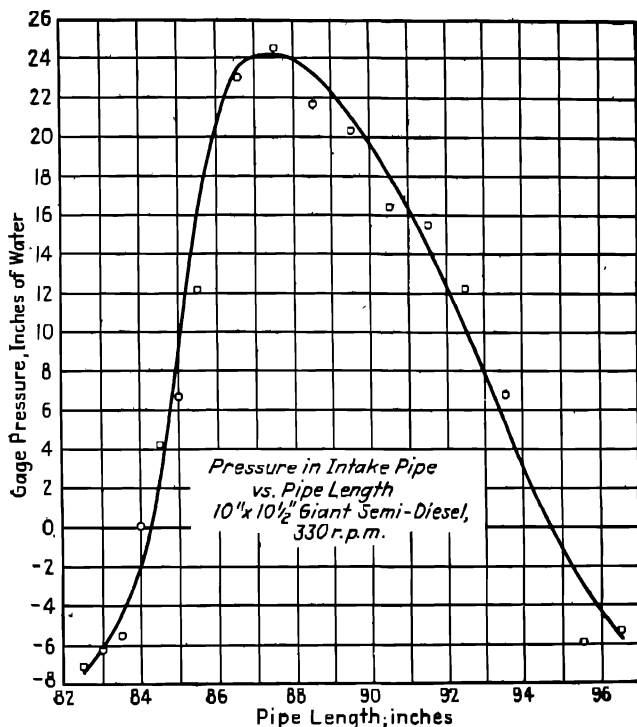


FIG. 14.—Showing graph in which a smooth curve is drawn to fit points established by test. (*Power*, p. 453, August, 1934.)

certain kinds of factual material. In general the engineer will find it advisable to employ experts for making the exposures when photographs are desired. He should make clear to the expert the particular phase of the situation that he wishes to bring out in

the photograph and depend upon the photographer to secure the proper lighting, exposure, and other factors necessary for successful photography. However, many engineers have employed the method of photography extensively and have become expert in taking photographs.

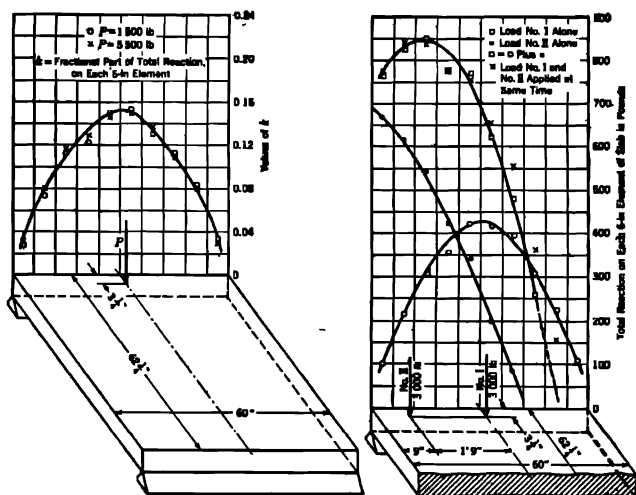


FIG. 15.—Ingenious diagrams devised to show test results. (*Civil Engineering*, p. 591, November, 1934.)

Photostats.—Most of the diagrams employed in reports will be produced in the form of drawings of such a size that it is convenient to perform the drafting. These will frequently be larger than a page of the report, and it is desirable to avoid folded sheets whenever possible. If the report is to be printed, reduction to page size or less is readily accomplished in the process of producing the zinc etchings or litho-

graph plates employed in printing. If the report is to be typed, the drawings can be reduced to page size by the photostat process and black-line reproductions produced that are very satisfactory. The appearance

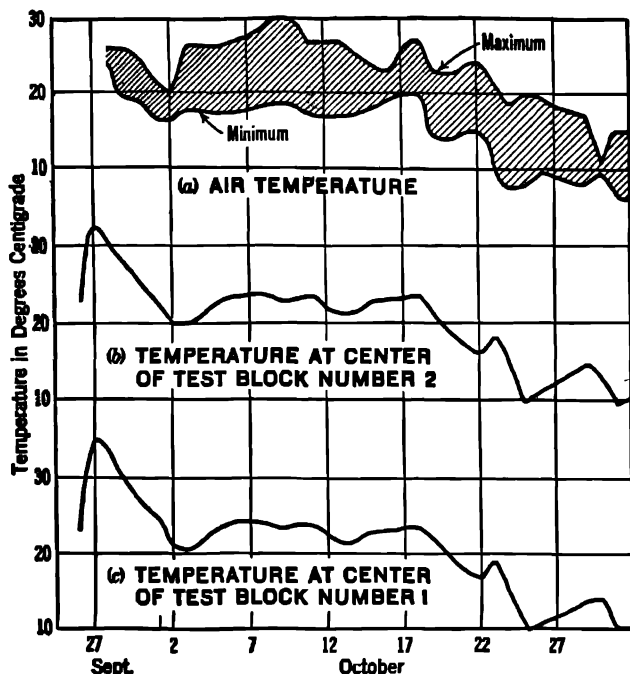


FIG. 16.—Type of graph used to present a simple research condition.

of the report in which black-line figures are used is much superior to the one in which blueprints are inserted. In fact blueprints are no longer extensively used for illustrating reports.

A word of caution is in order with reference to the lettering and figures on drawings that are to be reduced

in size by some reproduction process. The lettering on the originals should be made to such a scale that after reduction it will still be legible and this should not be left to guess. On the contrary the size of letter required on the original drawings to insure the legibility of the reproductions should be worked out arithmetically for the desired reduction. Also, great care should be exercised to avoid crowding of the lettering. A broad, open style of letter or figure, widely spaced, is best.

Summary.—The development of each chart or graph is a problem in design, and a little effort spent in devising a simple and effective method of presenting data will usually be well repaid by the appearance and clearness of the resulting figures. It is well to strive for simplicity and clearness, as complicated or crowded diagrams may be misunderstood or perhaps cause impatience on the part of the reader. On the other hand, well-designed illustrations add greatly to the clearness and value of a report.

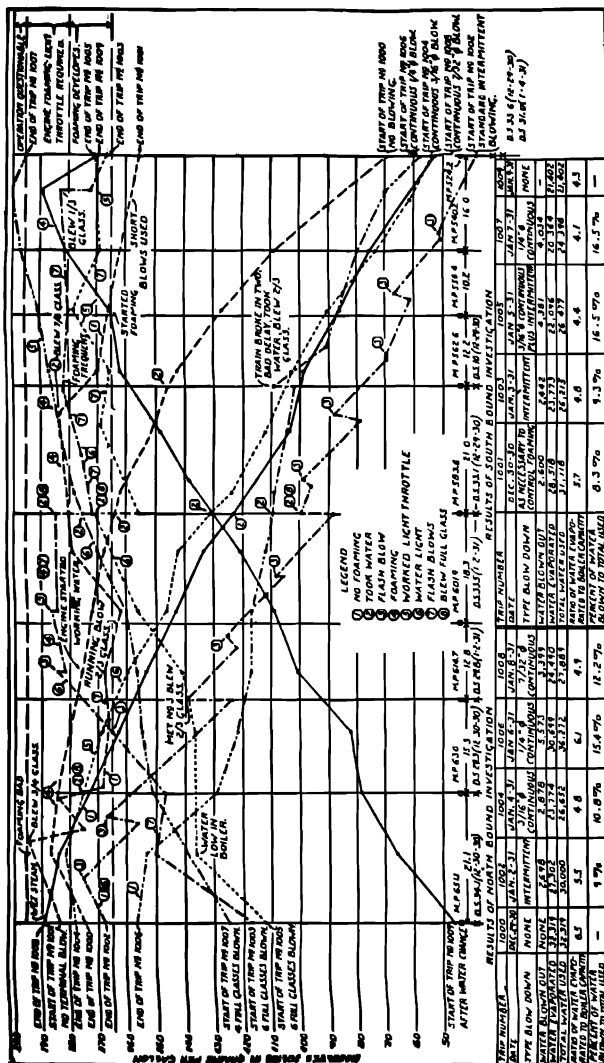


FIG. 17.—Showing diagrammatic presentation of a very involved research on the foaming of locomotives. Note: This diagram is too crowded and complex for other than technical readers familiar with the problem.

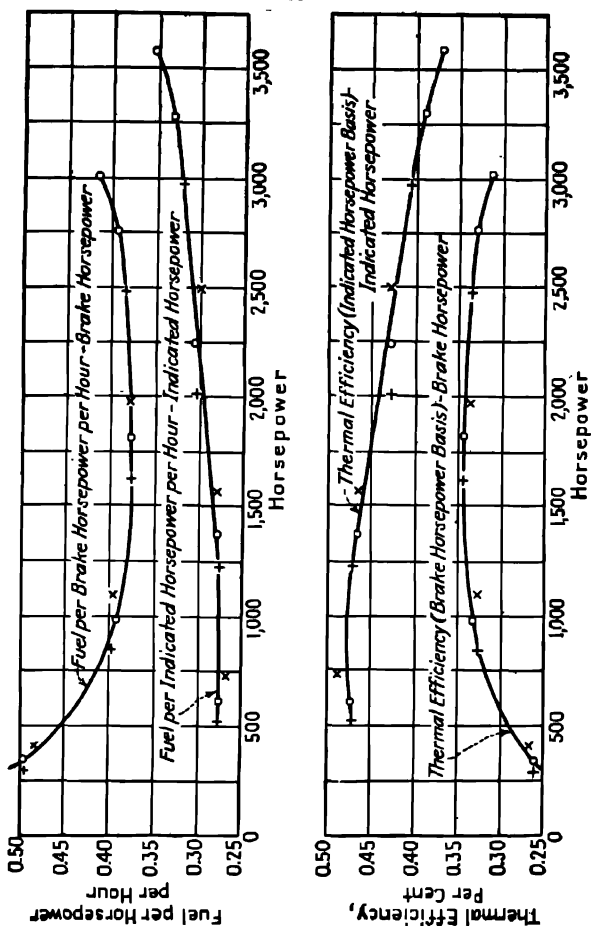
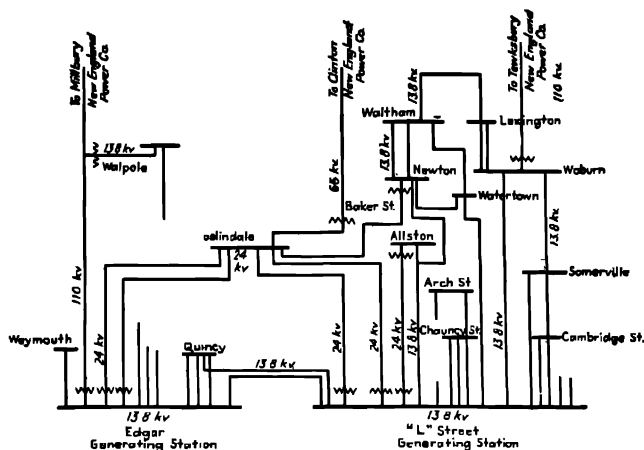


Fig. 18.—Showing graphs drawn through calculated points (indicated by o) and checked by test data (indicated by X). [*Engineering (London)*, p. 713, Dec. 4, 1931.]



Basic scheme of generating plant, substations and transmission facilities

Limited portion of the Boston Edison system with principal interconnections

FIG. 19.—Diagram used to show graphically the basic scheme of generating plant, substations, and transmission lines of an electric utility. (*Electrical World*, p. 147, Aug. 4, 1934.)

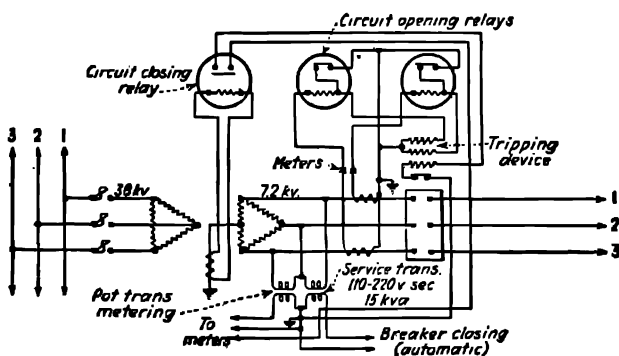


FIG. 20.—Showing conventional method of presenting electrical-circuit data. (*Electrical World*, p. 111, July 28, 1934.)

CHAPTER VIII

FORM REPORTS

Prior to entering college and during the first weeks in college, the student has numerous occasions to "fill out forms." A person who is seeking a position will in many cases be required to fill out a form of application and upon being employed will probably fill out a personnel form for the company's records. In engineering practice, report forms are used extensively in the routine necessary to the functioning of an engineering staff.

The reports for which prepared forms are provided usually cover routine matters—the things done repeatedly day after day. The college authorities in requiring the student to fill out the registration blank wish to know where the student lives, his telephone number, who his parents are and where they live—facts of apparently small importance, but of great significance in case the student is involved in an accident or becomes seriously ill. Certain of the laboratory-report forms which the student uses only once during his college career are employed in the commercial laboratory every time the particular test is made. The reports made daily or weekly by the young engineer in professional work are often looked upon as a nuisance and perhaps appear to have little value but, when combined with similar

reports made by the other men in the organization, furnish a complete and current record of the work of the organization.

Purpose of Form Reports.—A form report is employed where it is necessary to secure and record some type of information repeatedly with assurance that in each report on a particular subject there are included the proper data reported in exactly the same form. For example, a plant may have the custom of making periodic examinations of the boiler feed water, and the reports of these analyses are filed after examination. At some later time it may be desirable to draw some comparison between the characteristics of the boiler feed water and the performance or economy of the boiler plant. If each of the analyses is complete and if the results are expressed in the same unit throughout the series, the information thus available will be convenient for use in the study of boiler-plant efficiency. On the other hand, if each test were reported in a letter the record would probably be unsatisfactory in several ways. In the first place, the data would probably not be reported in the same way in each letter, and each report would need to be read carefully to make sure how the data were arranged. In the second place, the laboratory might not report exactly the same information on each test, or if it did report exactly the same information it might not report it in exactly the same units. In the third place, it would require more time to write the report in letter form than it would to fill out the form report.

A report form is therefore employed in those cases where a certain type of data is to be presented at

intervals, and it is desirable that these reports should be exactly alike in form and in content, except for the numerical data relating to the problem. There are several very definite reasons why the report should be made this way. When the person who prepares a report has only to fill in the data asked for, he can do it much more quickly than he could write a letter giving the same information. The form report is also a time saver in the office because specific data are much easier to analyze than general information in a letter. There is less danger of pertinent information being omitted when the form report is employed than when an attempt is made to give the same information by letter. The form report is usually designed by a person who is familiar with every detail of the work to be reported on and who knows just what the report should contain to cover completely the requirements of the particular work. If the letter report is employed even by persons familiar with all the details of the use of the report, it is doubtful if everything will be covered in the same way in each report. Frequently, form reports are used to compare the results obtained on one job with those on some similar job in progress or completed. It is therefore important to secure uniformity both in the method of making the report and in the units involved. Since the report is outlined on the blank, each person making a report will use the same methods and the same units and the results obtained on any job can be compared with those of another or with the estimates for the job.

Form Reports Answer a Question.—The form report as it is employed in engineering work, as well as in many other fields, furnishes the basis for the answer

to a question. In many cases the answer to the question is not determined by the person who fills out the form report, that duty being reserved for some more experienced person who will examine the material later on. Nevertheless, it should be recognized that the form report, as employed in engineering practice, is a true report and is a means of answering a question. The answer to the basic question may be arrived at by considering the answers to a number of other questions. The report form for a boiler test provides for the inclusion of a considerable amount of test data taken during the test run, but the ultimate purpose of the material is to permit an answer to the question: What is the efficiency of the installation?

The report on routine tests of portland cement will usually be made on a prepared form, upon which will be recorded the answers to such questions as: What is the time for initial set? What is the time for final set? What is the mechanical analysis? The standard mortar strength? The real purpose of the report is to answer the question: Is the cement of the quality contemplated by the specified standards?

It was pointed out earlier in this treatise that formal engineering reports are sometimes prepared without expectation of reaching a conclusion on the basis of that particular report but to present certain information which will be available to the profession and which may later contribute to the answer to a question. The same thing is true of form reports. These are sometimes employed for the accumulation of data which later may be assembled and may afford an answer to a question, whereas the material on any one report would not permit such an answer. The

questionnaire is really a form report which is used to secure data to be used as a basis for the answer to a question.

Periodic Reports.—The form report probably has its most extensive use in connection with the periodic reports that are required in engineering operation and on construction. In the operation of industrial plants, it is usual to require daily reports on certain phases of the operation, such as the fuel, labor, and other items of cost of power, or the details of the output of a particular shop. In the construction field, reports are required periodically to show the progress of the construction on a particular contract, the quantities of materials received and used, the records of the tests of materials that have been examined in the laboratories, and like information. For these purposes the form report is almost universally employed.

Occasional Reports.—Report forms are widely used also in connection with certain types of operations or activities that are intermittent or occasional in character. Forms are widely used for the reports that are made by testing laboratories on occasional tests of materials that come in from clients; the report on the acceptance test of a new boiler plant; the report that is made up as a preliminary to construction; final acceptance reports on construction projects; and similar cases in which it is desired that the report cover certain information that experience has demonstrated to be necessary for forming a correct conclusion and a complete record of the particular work.

Essential Elements of Form Reports.—It will simplify the preparation of forms to be used for

reports if it is clearly recognized that in their essential characteristics form reports are an abridged arrangement of formal reports. In general the form to be employed for this purpose will provide for the assembly and tabulation of data in an amount and of the character that would be included in a formal report covering the same subject. The report form is used to secure uniformity and completeness and serves to remind the person who is filling it out that certain kinds of data are necessary to afford the basis for the proper conclusion in the given case, and that the information should be presented in a certain order and in certain units.

The first feature that needs to be considered is that of insuring proper identification for the particular report. The form should provide spaces to be filled in showing where, by whom, and when it was filled out. It should show, without possibility of misunderstanding, the particular project or problem upon which the report is being made. These data will appear at the beginning of the form for the convenience of those who handle the report and to provide identification to facilitate filing. Following the identification sections there will be a series of blanks with appropriate notations to permit filling in all of the data needed for the purposes of the report. Here the problem is that of making entirely clear just what information it is expected will be written into the blank space that is shown. To do this, it is desirable to follow closely the terminology and customs of the particular field of engineering, and in specific organizations terms are frequently employed with a special meaning which is well understood in that organization

but might not be understood outside. Terms of this character are perfectly satisfactory for forms to be used for reports provided explanations are available to indicate the meaning of the terms.

Since the whole purpose of using a form for a report is to insure accuracy and brevity, together with completeness, it often proves desirable to arrange the material on the form in a manner that will conserve space rather than in accordance with any particular sequence of thought. However, if computations are to be made on the form, or after the report has been received, space should be left at appropriate places to permit inserting the figures that will be the result of such calculations.

A form to be employed for reports should carry detailed instructions as to the information to be included. A convenient method of accomplishing this is to number each of the items on the blank and under a corresponding number to give directions pertaining to that item. Exceptions are when the information desired is self-evident, such as dates and places, and cases where the desired information can be indicated in small type under the line that is to be filled in.

The Design of Report Forms.—The practice in the design of report forms is to secure as many as possible of the report forms used for a particular purpose by some other organization, and to employ these as a basis for the desired form. It seldom happens, however, that a report form can be developed and put into use without it proving necessary to make extensive revisions after experience has been gained with the form. A good procedure is to prepare what

appears to be a suitable form and to use it in mimeographed form for a time and then, as experience indicates how it should be revised, gradually bring it into a satisfactory final form. When this has been accomplished and the form has been tried out repeatedly, it ordinarily will be printed. As experience is gained, even with printed forms, it usually proves to be possible to improve them by an occasional revision.

Forms have been developed by some of the national technical organizations which have become standard for certain kinds of reports. Laboratory-report forms have been developed by the American Society for Testing Materials for reporting tests on materials. The boiler test code and report form developed by the American Society of Mechanical Engineers is another good example of such standardization. The Associated General Contractors have published a number of forms to be used in preparing bids and financial statements. Forms of this kind should be used wherever applicable since the information contained in them is used extensively by the engineering profession for comparisons, and uniformity in the method of presenting the data is very important. It is not so likely that the forms developed in an ordinary engineering organization for collecting data for its own use will fit the condition in another organization.

The size of the sheet or card on which the form report is printed depends upon several factors. The first of these obviously is the amount of information which must be entered on the report and the way it is to be entered. Reports which require much written material or many figures should be made of such size that the writing or figures need not be crowded or

made so small as to be illegible. The form should always be made on cards or sheets that are standard commercial sizes. There are two good reasons for this: The standard size is always the cheapest and, in addition, standard filing equipment may be used. If the reports are on cards, these should be 3 by 5 inch, 4 by 6 inch, 5 by 7 inch, or some other size that fits a standard file. The most convenient size for printed forms is the letter size, 8½ by 11 inch. This size is large enough for most report forms and is convenient for filing. When an 8½ by 11-inch sheet is not large enough for the proper arrangement of the data, the sheet may be made larger but should be of such shape that it can be folded into the 8½ by 11-inch size.

To a certain extent, the size adopted will depend upon the person who is to make the report. If the report is made by a foreman or laborer in the field, the form should be of such size that it can readily be carried in the pocket. If the information required from field men is so voluminous that it is impossible to get it all on a sheet or card that can be carried in the pocket, there may be several reports each covering one of the more important operations. If the person who makes out the report has an office, even a temporary one, the report form may be of any desired size.

The ability of the man who is to make out the report should be kept in mind by the designer of the report form. If it is probable that the report will have to be prepared by a laborer with little or no education, then the form should be so designed that he will have very little writing to do. A punch card

form upon which crosses may be made in squares, or letters or figures inserted in designated spaces, is convenient for many types of form reports. Symbols should be used wherever possible to designate the various operations. Terms used on the form for classifying the work should be the ones current in the field of endeavor under consideration.

Some Uses of Form Reports.—Form reports are utilized in a variety of ways in engineering work but the one most common is for exercising control over work and for reporting the results of tests and field examinations or on inspection work. The material included in the report is later made use of for various summaries of operation or costs or for designs and for administrative action to lower costs. The report of the survey of the site for a bridge would be sent directly to the designing engineer of the bridge department and the data would be used in designing the bridge for that location. After the bridge had been designed and built, the report would have little value but would probably be filed for future reference.

On construction work, the daily reports of all operations are sent first to the job superintendent. He compares the results being obtained, as shown by the report, with the estimates, learns where material is needed, which crews need to be increased, the progress made by each crew, the cost of the work, and which phases of the work need his personal attention. After the job superintendent has finished with them, the reports may be turned over to the timekeeper who would use the information in them to make the distribution of the payroll. The timekeeper may then send them directly to the main office or he may

summarize the data and make a consolidated form report which furnishes a picture of the financial status of the project.

The Value of Form Reports.—It is obvious that the management must depend upon the field man who makes the report for the accuracy and completeness of the detailed information which reaches him. If the field man is conscientious and fills out the form report carefully, the information in the report will afford a sound basis for the establishment of management policies. The employee who prepares a form report should be sufficiently familiar with the purpose of the report to form a judgment as to the data necessary to fulfill that purpose. However, in the long run the main dependence for acceptable reports must be placed on the report form and the instructions that accompany it. If the report form is well-designed and the instructions are clear, any person worthy of being given a responsible position, even though a minor one, should be able to prepare a report that is entirely adequate for the purpose to which it will be applied.

EXAMPLE OF A FORM REPORT

DAILY TIME DISTRIBUTION

AND
WORK ACCOMPLISHED

County Project No.

Name of Road Contractor

Sup't or Foreman Date 19

TIME DISTRIBUTION										WORK ACCOM- PLISHED
No. of Men										
Operation	Supt.	Foreman	Teamsters	Laborers	Tractor Eng.	Teams	Ele. Grader	Tractor	Fresno	Wheelers
Clearing of R. of W.										Sq. Rds.
Fencing										Rods
Rough Grading	Earth									Cu. Yds.
	Loose Rock									Cu. Yds.
	Solid Rock									Cu. Yds.
Sub-Grading										Sq. Yds.
Paving and Graveling										...Yds.
Shoulders										..Yds.
Finishing										...Yds.
Guard Rail										Lin. Ft.
Tiling										Lin. Ft.

Weather:

Cut Sta. to Sta. Hours

Borrow Sta. to Sta. Hours

Earth deposited Bst. Sta. and Sta.

Condition of Earth being moved

Remarks:

..... Engineer

APPENDIX A

SUGGESTIONS ON STYLE

A study of the various technical periodicals and the publications of the engineering societies indicates that considerable variation in style is to be expected among publications of unquestioned merit, and even in a single issue of one of these publications. These variations are found in the use of abbreviations, capitalization, size and style of type, and similar features. The engineering report that is to be published will usually be brought out in the style adopted by the agency that publishes it, regardless of the style followed in the manuscript. When published by the writer, he can, of course, control the style of the printing and should follow that which is employed by some one recognized technical publication with which he is familiar, preferably the publications of the professional society dominant in the field covered by the report.

The following suggestions on style are intended for reference in connection with the preparation of type-written reports although most of the material is also applicable to printed reports. It is realized that in many respects these suggestions differ from the usage in certain technical publications since no set of rules on style seems to be universally accepted. Those included herein may be followed with assurance that

there is good precedent for each. The suggestions on abbreviations and punctuation are intended to cover some of the commonly recurring questions that confront the busy engineer when he finds himself in the midst of the task of writing a report and wishes to know whether to write B.T.U., b.t.u., or B.t.u.; counter-shaft or countershaft.¹

Capitalization

In technical papers, reports, and discussions, many words are capitalized which would be left uncapitalized in newspaper articles, letters, and other informal writing. Although practice varies, the following rules may be followed with assurance in the preparation of formal papers. It is the present tendency to capitalize sparingly.

Capitalize :

1. The first letter of proper names or words used as such:

¹ The principal authorities consulted in preparing these Suggestions on Style were:

1. "Style Manual for Authors and Editors," American Society of Mechanical Engineers, New York, revision of 1930.
2. "General Information on Society Publications and Preparation of Manuscript for Proceedings," American Society of Civil Engineers, New York, 1931.
3. "Regulations Governing the Form but Not the Substance of Standards," American Society for Testing Materials, Philadelphia, 1921.
4. "Copy-desk and Proof Room Style," McGraw-Hill Publishing Co., Inc., New York, 1931.
5. "A Manual of Style," University of Chicago Press, Chicago, 1925.

James Brown, England, English, Congress, Congressional

2. The first word of a sentence.
3. The first word of a direct quotation:

He said, "Ship 30 tons of 85-lb. rail."

4. The first word following a colon if the colon is followed by an enumeration or a sentence element having an independent meaning:

The investigation established this fact: The failure was not the result of faulty design.

5. The principal words in center and side or paragraph headings, in the titles of books, formal papers, theses, reports, and proceedings, and all parts of the verb "to be" except that "to" is not capitalized in the infinitive form. Always capitalize the last word in a title. Do not capitalize prepositions, conjunctions, and articles unless they stand at the first of the title or contain more than three letters:

Railway Signaling, The Elements of Engineering Drawing, Work to Be Done

6. All titles of honor and respect immediately preceding the name of persons.

Exception: In addresses and signatures capitalize both before and after the name. The term president, when referring to the President of the United States is always capitalized:

Dean Friley, Dr. Chas. E. Friley, Dean of Industrial Science

7. Any term immediately preceding a roman numeral, indicating a subdivision of a report:

Vol. I, Part II, Section V

Exception: Do not capitalize minor subdivisions and their abbreviations in a literary reference:

pp. 352-353

8. All geographic terms, singular or plural, when they are used as part of the name:

Mount Blackburn

Rocky Mountains

Pacific Ocean

Croton Aqueduct

Indian Creek

Mississippi Valley

Exceptions: Do not capitalize in such expressions as *valley* of the Mississippi or the *mountains* of the Cascade Range.

9. The names of streets, parks, roads, buildings, and the like:

Lincoln Way

City Hall

Central Park

Post Road

10. The names of political parties:

Democrats

Republican Party

11. The official titles of legislative acts and bills, organizations, and institutions:

American Society for Testing Materials

Illinois Society of Engineers and Surveyors

Engineers License Law

The Federal Aid Highway Act

12. The names of important historical events:

World War

Haymarket Riots

Gadsden Purchase

13. Abbreviations for degrees and titles:

Ph.D., B.S., E.E.

Note: The letters in such abbreviations should not be spaced except as required for punctuation.

14. Abbreviations consisting of one letter except in units of measurement:

70 deg. F. (Fahrenheit), 40 l. (liters), 1,000 m. (meters)

Do Not Capitalize :**15. Abbreviations for before noon and afternoon when used with figures:**

4:30 a.m.

6 p.m.

16. The points of the compass when spelled out; except when used to designate a part of the country or when used as part of a street or other name:

east, northeast

The building faces east. He followed a practice common in the East. East Lansing, Mich. East High St.

17. Words of common usage derived from proper names:

bessemer steel, monel metal, macadam, portland cement

18. Academic degrees when spelled out:

master of science, doctor of philosophy

19. Names of the seasons of the year:

spring

Abbreviations

In engineering reports and technical articles, it is the general practice to avoid abbreviations in the text although they may be employed in tabular matter and in footnotes of reference. When abbreviations are considered desirable, only those should be used which have been established by usage in the standard engineering publications and with which engineers may be expected to be familiar. The rules which follow, outline the more usual uses of abbreviations (see Appendix B).

1. Abbreviations should be capitalized when the word, if spelled out, would be capitalized:

Fig. 1. Sec. IV. Bangor, Me.

2. The letters in compound abbreviations should not be spaced except as required for punctuation:

B.t.u. cu.ft. Am.Soc.C.E.

3. Sentences should not begin with abbreviations except that it is proper to begin with an abbreviated title such as "Mr." or "Dr.":

Mr. White discussed this case.

Dr. Brown tested a number of specimens.

Col. Morse directed the construction.

4. Names of countries should not be abbreviated with the exception of United States which may be abbreviated when used adjectively in the names of departments or divisions of government:

U. S. Department of Agriculture

5. Names of provinces, states, or departments of a foreign country, except Canada and Mexico, should not be abbreviated. States of the United States may be abbreviated according to the schedule in Appendix B.
6. Abbreviations for plural terms should be the same as for singular terms:

1,000 kw-hr.

50 in.

Exceptions: Figs., Nos., Aves., Gens., Drs., and Profs.

7. The words "figure" and "number" should be abbreviated and capitalized when followed by a numeral except at the beginning of a sentence.
8. Names of the months except March, April, May, June, and July may be abbreviated when followed by a numeral denoting the day of the month:

March 1, 1935, Dec. 2, 1932, on the second day of November.

9. Figures indicating the day of the month are not usually followed by "nd," "d," "st," and "th." Numbered street names, however, carry the terminating letters after the numbers:

March 1, 3d St., 21st St.

10. Mountain, mount, fort, port, and point when used in a geographical sense should not be abbreviated:

Lookout Mountain, Mount McKinley, Fort Snelling, Point Barrow, Port Townsend. Power from a mountain stream. . . .

11. Titles should be abbreviated only when followed by the full name:

. . . as taught by Prof. J. E. Nelson. . . . as taught by his professor. . . . served under Col. John Fry. . . . later became a colonel. . . . consulted Major Johnson.

12. East, south, and similar words should be spelled out when used as a part of the name of a street or region:

71 West 12th St., East Pittsburgh, Northwest Territory.

13. Use the ampersand (&) with Bro., Bros., Co., Ltd., Inc., and Corp. in firm or corporate names:

Illinois Steel Co., Montgomery Ward & Co., Chicago & Northwestern Railway Co., Imperial Oil, Ltd.

But use the form

Story County Trust and Savings Bank
Brown and Cook, Civil Engineers

14. Use "and" to connect proper names in a personal relationship as in literary or scientific activities:

Harger and Bonney's Handbook, Dana and Wilmarth's slide rule

15. Descriptions of public lands when abbreviated should follow the forms given below:

N. $\frac{1}{2}$ NE. $\frac{1}{4}$ sec. 1, T.2N., R.3 w. of Boise Mer.
N. $\frac{1}{2}$ sec. 20, T.7 N., R.2 w. of 6th Prin. Mer.

Numbers in Headings for Tables.

When tables are numbered, roman or arabic numerals may be used but preferably the roman. Use a period and dash after the table number in the heading if followed by a title, otherwise use the period only:

Table X.—Receipts for Fiscal Year 1927
Table X or Table 10

Numbers in Captions for Illustrations.

Arabic numbers should be used in captions for illustrations. Use a period and dash after the figure number, if followed by a legend; otherwise use the period only:

Fig. 6.—Plan and elevation of boiler room.
Fig. 6.

PUNCTUATION

Because the readableness and clearness of a report are enhanced by correct punctuation, the importance of its use cannot be overestimated. There is a commendable tendency to reduce to a minimum the number of punctuation marks used but none should be omitted that will affect the clearness. Punctuation may be likened to the voice inflections of the orator. A speech delivered in a monotone is dull and hard to follow, and a report without proper punctuation is hard to read and difficult to understand.

The following rules for punctuation include those cases ordinarily encountered in report writing.

The Period

Use the period :

1. After every complete declarative and imperative sentence:

The building has been completed.

Deliver 10 sacks of cement.

2. After a question of courtesy which is really a request:

When the steel is delivered, will you see that it is placed properly.

3. After abbreviations in general (see Appendix B for exceptions):

C.E., Supt., Gen. Mgr.

4. As a decimal point:

The stock is worth \$3.75 per share.

5. To show that words have been omitted from a quotation, three periods separated by spaces.

Do not use a period after :

1. Per cent and certain mathematical or chemical symbols:

sin, cos, log, Na, H, Fe

2. A number which stands at the head of a column in a tabulation.
3. Titles, legends for tables, chapter headings, center headings, and individual parts of a table of contents or other like tabulation, the column headings in tables.

The Comma

Use the comma :

1. Before the conjunction connecting the two coordinate clauses of a compound sentence if the coordinate clauses are not directly related:

The cement house had been built, and the ground prepared for the stock pile.

2. To separate a series of words or phrases when the conjunction is omitted:

Lake Superior iron ore comes from the Marquette, Menominee, Vermillion, Gogebic, Mesabi, and Cuyuna ranges.

3. Before "and," "or," and "nor" when used for connecting the last two members of a series of three or more words or phrases:

He has worked for the Burlington, the Rock Island, and the Northwestern.

4. After a participial clause or dependent clause preceding the main clause of a sentence:

Three days after the pouring is completed, the forms may be removed.

5. Before and after non-restrictive and explanatory phrases and clauses:

The steel which came from Pittsburgh, the city of smoke and fog, was shipped over the Baltimore & Ohio Railroad.

6. After "said," "remarked," "replied," and similar words preceding a short quotation:

Mr. Crosley said, "There is no good definition for the term ballast."

7. To set off a descriptive phrase:

Mr. John Smith, of Buffalo, designed the steel frame.
John Doe, assistant engineer, represented his chief.

8. In addresses:

John Smith, 2913 Michigan Ave., Chicago, Ill.

9. In a date line between the day of the month and the year, and the day of the week and the month:

March 15, 1932

Monday, April 18, 1932

10. Between the subject and the verb to indicate the necessary pause when the subject is very long:

Anyone who enters the construction field and expects to succeed, must use business methods.

11. To separate the elements of a sentence when there is a possibility of the meaning being misunderstood:

We had nearly completed the trip when the train stopped, delaying us nearly an hour.

12. To set off mild interjections and slightly parenthetical expressions:

The machine, therefore, does not comply with the specifications.

But *not* in, "And therefore the machine failed."

Do not use the comma :

1. To set off restrictive clauses:

The truck that you saw was his.

2. To separate the clauses of a complex sentence when the main clause precedes:

The masonry can easily be demolished if the powder is properly placed.

3. When a series is composed of adjectives and each preceding adjective modifies the others in combination with the noun as a whole:

A smooth white durable paper can be made from cornstalks.

4. Before and after a phrase separating a conjunction and the verb:

He read the report and without further investigation decided to proceed with the project.

The Semicolon

Use a semicolon :

1. To separate the units of an enumeration if commas are used within the enumeration or if a greater degree of separation is desired than commas afford:

The following chief engineers were witnesses: Mr. Hadley, of the Missouri Pacific; Mr. Main, of the Union Pacific; Mr. Dike, of the Northwestern; and Mr. Davis, of the Great Northern.

2. Between the independent clauses when they are combined in one sentence for the purpose of adding force to the statements:

This is true of the railroads; it is true of the common carrier truck; it is true of the barge line.

3. Between the clauses of a compound sentence when they are joined by the adverbial conjunctions "also," "accordingly," "besides," "consequently," "furthermore," "hence," "moreover," and the like:

The derrick was unsafe; nevertheless they proceeded with the erection of the steel.

4. Between coordinate clauses that are not joined by a coordinating conjunction:

John handled the Kossuth County work; I had charge in Union County.

5. Between the members of a compound sentence when any member contains elements separated by commas, especially when the connective is omitted:

Contracts were to be let for work in Montgomery, Polk, and Union counties; the best work, however, was in Union County.

The Colon

Use the colon:

1. To separate a long quotation from the rest of the sentence; before any quotation where formality is sought.
2. Before any quoted matter which begins a new paragraph:

The president addressed the convention as follows:
"Gentlemen, this new regulation affects the pocket book of every man here."

3. Before an enumeration of a series of items following a pointing word, such as "this" or "the following":

Ship the following immediately: 6 barrels of gasoline, 3 barrels of No. 40 cylinder oil, and $\frac{1}{2}$ barrel of transmission grease.

4. To precede the expressions "namely," "that is," and "for example" when they introduce a series of terms used in apposition to the general term:

The report has been approved by several well-known engineers: namely, John F. Stevens, Hugh Cooper, and John R. Freeman.

5. To separate elements of time:

The test ran continuously from 12:45 p.m. to 1:46 a.m.

6. In certain ratios, as $1\frac{1}{2}$:1, when meaning a slope of $1\frac{1}{2}$ horizontal to 1 vertical; or in such expressions as a 1:2:4 concrete mix.
7. After the salutation of a letter.

The Apostrophe

Use the apostrophe:

1. To form the possessive:

The engineer's transit, the driver's truck, the spiker's mauls, the mason's helpers, John Cass' design, the engineers' quarters

2. In such phrases as a year's work, printer's ink, the miner's inch.
3. To indicate omitted letters in contracted words: don't, can't.
4. With "s" in forming the plurals of letters, numbers, figures, and symbols: a's, 9's.
5. Joint possession is indicated by adding the apostrophe and "s" to the last-named person:

Breed and Hosmer's Textbook

6. The apostrophe is never used with the possessive pronouns.

The Question Mark

Use the question mark :

1. After every direct question.
2. Within parentheses after a statement concerning the accuracy or authenticity of which there is some doubt:

The bridge was completed Jan. 15 (?), 1875.

Do not use the question mark :

1. To express irony or sarcasm.

The Exclamation Point

Use the exclamation point :

1. After a statement expressing strong feeling or emotion. It is doubtful if this mark should ever be used in report writing.

The Dash

The use of the dash should be avoided except where it is plainly the most appropriate mark. Usually the comma or the semicolon will do just as well.

The dash may be used :

1. To set off a parenthetical expression:

The deeper this caisson is sunk—and you will discover this as the work proceeds—the more difficult it will be to keep the water out.

2. Before a repetition for effect or explanation:

He was always noted for his fidelity to his work—a fidelity which drove him night and day.

3. Before a statement of particulars and also before a summary of particulars:

A solid has three dimensions—length, breadth, and thickness. Reputation, money, friends—all were sacrificed.

4. Before an author's name at the end of a quotation:

—C. F. Allen

5. After the number of a figure or table and after a paragraph heading:

Table I.—Results of Tensile Tests

Fig. 3.—Map of the Tract.

Tests.—The tests were . . .

The Hyphen

The hyphen is used between the words of a compound expression whenever there is a possibility that the meaning of the expression may not be clear. Since there is a tendency to combine words commonly used together into one word, it is only by careful observation of published material and frequent use of some standard dictionary that one can be reasonably sure of the use of the hyphen.

Use the hyphen:**1. To indicate the joining of words to express one idea:**

so-called, ill-advised

2. In fractions:

one-half, three one-hundredths

3. Generally in compound adjectives preceding a noun:

well-known expert, 6-inch channel, 3-ply board

4. Between a prefix and a proper noun:

semi-Diesel

5. In a suspended expression like:

computations of original- and reproduction-cost values

6. In lengthy compound attributes:

reproduction-cost-less-depreciation theory

Do not use the hyphen**1. In today, tomorrow, tonight.****2. When two words are joined to make another noun:**

roundhouse, eyebar, headgate

3. Between an adverb ending in "ly" and an adjective:

newly installed boilers, freshly mixed concrete

4. With prefixes of one syllable:

inoperative, belated

Use of the Hyphen in Compounding Words

1. Hyphens should be used between two nouns denoting a combination of equal things; between numbers denoting fractions:

surveyor-general, two-thirds

2. Compound words should be hyphenated when the hyphen is needed to avoid ambiguity:

He is manager of the new-business department.

3. The principal compound points of the compass should be written as single words; all others should be hyphenated:

northeast, north-northeast

4. Compounds that indicate a combination of systems, forces, methods, or colors should generally be hyphenated, but consult the dictionary before doing so:

hydro-electric, series-parallel, auto-transformers, blue-gray

But combinations such as electric machines, bluish gray, and similar forms should not be hyphenated.

5. Compounds with the prefixes "dis," "mons," "multi," "poly," "pre," "mis," and "super" should be written as one word unless the compound is an unusual one, such as "multi-special," or one formed for convenience, such as "mis-designated."

6. The suffixes "fold" and "score," when used with words of one syllable, should be combined therewith, without hyphens:

twofold, fourscore

When used with words of more than one syllable, "fold" should be preceded by a hyphen and "score" written as a separate word:

one hundred-fold, twenty score

7. Compounds with the prefixes, "after," "before," "counter," "cross," "in," "off," "on," and "with" are generally written as one word when the second part of the compound is one syllable. Otherwise they are generally hyphenated, but consult the dictionary in doubtful cases:

afterglow	crosscut	cross-section
after-effect	insight	countershaft
beforehand	offside	counter-revolution
onset	withstand	

8. Compounds with the prefixes "mid," "over," "under," "inter," "intra," "up," and "down" are generally written as one word, but there are a few exceptions:

overestimate	downstream	intramural
underground	midwinter	Mid-West
upgrade	interstate	

9. Compounds with the prefixes "be," "bi," "co," "de," "di," "pre," and "re" are not hyphenated except to avoid uncertainty of meaning:

re-cover the piping	recover the cook liquor
co-pilot	coincident

10. Compound nouns ending with "arm," "book," "light," "house," "plate," "room," "side," or "yard," and the like are written as one word if the first component of the combined word is one syllable; otherwise they are written as two words:

notebook, account book, flashlight, signal light, under side, outside, drafting room, tinplate, buckle plate, tieyard, storage yard

11. Usually words united to form compound adjectives should be hyphenated:

drafting-room personnel

12. Compound words ending with "like" are written as one word except where typographically objectionable, as when the first word ends with "ll" or consists of more than one syllable:

chalklike

bell-like

Parentheses and Brackets

Use parentheses :

1. To enclose incidental comment made by the author—matter injected to clear up a statement:

The hoist enginemen (who, by the way, were all from New York City) promoted the strike.

2. To enclose figures or letters that enumerate divisions of the thought:

The contributing factors in the failure were: (1) excessive pressure, (2) inferior materials in the structure, (3) inadequate safety devices.

But not when written in tabular form, as:

The contributing factors in the failure were:

1. Excessive pressure.
2. Inferior materials in the structure.
3. Inadequate safety devices.

Note: If a punctuation mark would ordinarily be required after that part of the sentence preceding

parentheses, put it after the second curve, even though the parenthetical expression is at the end of a sentence:

John Doe (a civil engineer), of Boston

If an entire sentence is enclosed in parentheses, the period should come before the last curve:

(This was discussed on page 108.)

Use brackets :

1. To enclose a longer sentence or clause which already contains a parenthetical expression:

The difficulty [and there is always difficulty (how well I know it!) where high temperatures are used] was due to inadequacy of the refractories with which the furnace was lined.

2. To enclose matter which is written into a quotation by somebody other than the author quoted.

Quotation Marks

Use quotation marks :

1. To set off a direct quotation:

Johnson said, "Cement will cost more next season."

2. To call attention to a word or phrase that is used in a special sense:

"Shimmy" was studied by means of a new device attached to the axle.

3. To direct attention to words used in an unusual way or to a preposterous or absurd assumption:

The "channel" referred to is a form of structural steel. The "technical expert" proved to be a man who had recently failed as a contractor.

4. To enclose anything preceded by "entitled," "the word," "the term," "termed," or "marked":

The device was termed an "odometer."

He made use of the word "catalyze."

5. At the beginning of each paragraph in a quotation of several paragraphs and at the end of the last of the series. *Exception:* If the quoted matter is typed indented or printed in type smaller than the text, the quotation marks are omitted.
6. Enclose in quotation marks the title of a book, article, report, or paper.

Do not use quotation marks :

1. With anything following "known as" and "so-called," unless the words are misnomers, slang expressions, or ordinary words or phrases used in an arbitrary sense:

The substance used is known as soda ash.

The type of hoist known as a "monkey"

Designed by so-called experts in

Sold a substance known as an "accelerator"

2. In printed matter to enclose foreign words, print in italics or type with underscoring.

Quotation Marks Combined with Other Punctuation Marks

1. The period and the comma are placed inside the quotation marks.
2. The colon, semicolon, exclamation point, and interrogation point should be placed outside

the quotation marks unless they are a part of the quotation.

Use of Italics

In general, italics should be used sparingly in a printed report, particularly for the purpose of emphasis. There are uses of italics, however, which are proper, and in typed reports italics may be indicated by underscoring the word or phrase.

1. Foreign words and phrases that have not become incorporated into the English language should be printed in italics:

pavement for a *cul-de-sac*
résumé of the method

2. Certain Latin references that have not become anglicized should be set in italics when used. Avoid the use of foreign words if there is an acceptable English equivalent and if foreign words (especially Latin or French) are used consult a standard dictionary for style.
3. Foreign terms that have become anglicized may be printed in roman if although practice is not uniform with respect to these terms:

etc. (*et cetera*), "and so forth"
i.e. (*id est*), "that is"
e.g. (*exempli gratia*), "for example"
viz. (*videlicet*), "namely"
v. or vs. (*versus*), "against"
et al. (*et alibi*), "and elsewhere"; (*et alii* or *alia*), "and others"

4. Names of publications mentioned in the body of the text should be printed in italics or typed

with underscoring, the address, if given, being roman.

5. Scientific names of plants, birds, fishes, insects, and the like, and the names of vessels are set in italics and typed with underscoring. This does not include the names of geological formations, constellations, stars, planets, or comets:

A small fly (*psychoda alternata*) sometimes breeds in filters.

A sight on Polaris.

Numerals

Usually all small numbers are written out but practice varies regarding which are to be considered the small numbers. One organization spells out each number up to and including ten; another, twelve; still another, twenty; and in at least one organization one hundred is considered the upper limit. The limit is not so important if the practice is uniform. Probably the most generally accepted figure is ten, all numbers above ten being expressed in figures. There are a number of exceptions to this rule, however, the most important of which are given below:

1. Use figures to denote:

- (a) Clock time: 9 o'clock, 7:30 p.m.
- (b) Definite quantities: 10 amperes, 500 pounds
- (c) Dimensions: 2 by 4 in., 2 ft. 4 in. by 6 ft. 3 in.
- (d) Distances: 1,500 yards, 4 ft., 6 in.
- (e) Measures: 1 bu., 10 cycles, 10 ohms
- (f) Money: 3 c., \$100
- (g) Percentages: 7 per cent, 10 % (tabular matter only)
- (h) Ratings: 60 hp., 200 kva., 40 watts
- (i) Temperatures: 68 deg. F., 10 deg. C.
- (j) Density: 19 deg. B.

2. Figures should be used in every instance where numerical values follow or precede abbreviations:

2 bu., 4 ft., No. 2.

3. Days of the month should be expressed in figures:

July 2, 1932

4. In any group of numerical statements, if some of the numbers are expressed in figures, use figures for all:

There were 2 angles, 10 channels, and 50 forgings.

5. In a series implying precision, use figures:

10 pounds, 4 ounces

6. Use figures where the number is partly fractional or decimal:

$3\frac{1}{2}$ miles, 2.2 tons

7. Do not begin a sentence with a figure unless it is an ordinal at the beginning of the sentence.

8. Round numbers should be in words, particularly when used in an indefinite sense:

about three feet

9. A number followed by another number should be spelled out:

ten 40-hp. motors

10. In expressing percentages use decimals:

4.5 per cent

11. Unnecessary ciphers should be omitted from sums of money, except in a column containing fractional parts of a dollar:

\$300, not \$300.00; also time of day 7 p.m., not 7:00 p.m.

12. In decimal numbers containing no units, a cipher should be placed before the decimal point:

0.173 0.7854

13. In pointing off a number of four or more figures, use commas. Spaces may be used instead of commas in tabulations.

In text: 1,234,567 In tables: 1 234 567, but always 0.159327

Note: Figures designating years, decimals, telephone numbers, page numbers, and street or avenue numbers are not usually pointed off by commas.

14. Numbers greater than 1,000, if spelled out, are expressed thus: one thousand five hundred and fifty dollars, except that when the calendar year is spelled out, it is written: "nineteen hundred and thirty-two."

Numbers and Letters Denoting Divisions and Subdivisions

1. When the numbers 1, 2, 3, etc., and the letters a, b, c, etc., are used in a report to denote divisions and subdivisions of a subject and do not introduce a paragraph, they should be enclosed in parentheses and in printed matter

the letters should be in italics and, if typed, underlined. Examples:

It is recommended that: (1) new specifications be prepared, and (2) a new call for bids be issued.

It is apparent that: (a) the fuel was not of good quality, and (b) no attempt was made to adjust the draft to the fuel.

2. When introducing a paragraph, the figures should be followed by a period and a space (no dash and no parentheses). The letters should be enclosed in parentheses (no dash and no period) and in printed matter should be in italics and underlined when typed. Examples:

21. The tests indicate clearly that:

1. The transmission line was in good condition.
2. The interference came from some powerful source.

15. The steps to be taken are:

- (a) Place a new lining in the stack.
- (b) Increase the boiler capacity by adding 100 hp.

Division of Words

1. The dictionary should be followed closely in the division of words at the end of a line.
2. Divisions placing a two-letter syllable either at the end or at the beginning of a line should be avoided.
3. Figures should not be divided at the end of a line.

APPENDIX B

ACCEPTED ABBREVIATIONS

absolute	abs.
acre	spell out
acre-foot	acre-ft.
afternoon	p.m.
air horsepower	air hp.
Alabama	Ala.
Alaska	spell out
alternating current	a.c.
ampere	amp.
ampere-hour	amp-hr.
Ångström unit	spell out
antilogarithm	antilog
April	spell out
Arizona	Ariz.
Arkansas	Ark.
article	art.
assistant	asst.
associate	assoc.
association	assn.
atmosphere	atm.
atomic weight	at.wt.
August	Aug.
Avenue	Ave.
average	avg.
avoirdupois	avdp.
barometer	bar.
barrel	bbl.
Baumé	B.
Birmingham wire gage	B.w.g.
board feet	b.ft.

board measure	b.m.
boiler horsepower	spell out
boiling point	b.p.
boiling pressure	spell out
brake horsepower	b.hp.
brake horsepower-hour	b.hp-hr.
Brinell hardness number	spell out
British Columbia	B.C.
British thermal unit	B.t.u.
Brothers	Bros.
Brown and Sharpe	B. & S.
building	blg.
bushel	bu.
California	Calif.
calorie	cal.
candle	spell out
candle-hour	candle-hr.
candle power	spell out
center to center	spell out or c. to c.
cent	c.
Centigrade	C.
centigram	cg.
centiliter	cl.
centimeter	cm.
centimeter-gram-second	cgs.
chain (surveying)	chn.
chemical	spell out
chemically pure	c.p.
circular	cir.
circular mil	cir.mil
coefficient	coef.
cologarithm	colog
Colorado	Colo.
concentrate	spell out
conductivity	spell out
Connecticut	Conn.
constant	spell out
continental horsepower	spell out
cord	spell out
corporation	Corp. in firm names

coscant	csc
cosine	cos
cotangent	cot
coulomb	spell out
counter electromotive force	counter e.m.f.
county	spell out
cubic	cu.
cubic centimeter	c.c. (liquids)
cubic foot	cu.ft.
cubic foot per second	cu.ft. per sec.
cubic inch	cu.in.
cubic meter	cu.m.
cubic millimeter	cu.mm.
cubic yard	cu.yd.
current density	spell out
cycles per second	spell out
cylinder	cyl.
day	spell out
December	Dec.
decigram	dg.
deciliter	dl.
decimeter	dm.
degree	deg.; ° may be used in tables
Delaware	Del.
diameter	spell out
direct current	d.c.
District of Columbia	D.C.
dozen	doz.
electric	spell out
electrical horsepower	electrical hp.
electromotive force	e.m.f.
elevation	El.
engine	spell out
engineer	spell out
engineering	spell out
equation	eq.
external	ext.
external secant	ex.sec
Fahrenheit	F.

farad	spell out
February	Feb.
feet per minute	ft. per min.
feet per second	ft. per sec.
Figure	Fig.
Figures	Figs.
Florida	Fla.
fluid	fl.
foot	ft.
foot board measure	f.b.m.
foot candle	spell out
foot Lambert	ft. Lambert
foot-pound	ft-lb.
foot-pound second	f-p.s.
forenoon	a.m.
free aboard ship	spell out
free alongside ship	spell out
free on board	f.o.b.
freezing point	spell out
frequency	spell out
furlong	fur.
fusion point	spell out
gallons	gal.
gallons per minute	gal. per min.
gallons per second	gal. per sec.
Georgia	Ga.
grain	spell out
gram	spell out
gram-calories	spell out
hectare	spell out
high-pressure	spell out
horsepower	hp.
horsepower-hour	hp-hr.
hour	hr.
hundred	spell out
American hundred-weight	100 lb.
English hundred-weight	112 lb.
hyperbolic sine	sinh
hyperbolic cosine	cosh
hyperbolic tangent	tanh

Idaho	spell out
Illinois	Ill.
inch	in.
inch-pound	in-lb.
inches per second	in. per sec.
Indiana	Ind.
indicated horsepower	i.hp.
indicated horsepower-hour	i.hp-hr.
intermediate pressure	spell out
internal	spell out
Iowa	spell out
January	Jan.
joule	spell out
July	spell out
June	spell out
Kansas	Kans.
Kelvin	spell out
Kentucky	Ky.
kilocycle	spell out
kilogram	kg.
kilogram-meter	kg-m.
kilograms per cubic meter	kg. per cu.m.
kilograms per second	kg. per sec.
kiloliter	kl.
kilometer	km.
kilometer per second	km. per sec.
kilovolt	kv.
kilovolt ampere	kva.
kilowatt	kw.
kilowatt-hour	kw-hr.
Lambert	spell out
latitude	lat.
linear	lin.
linear foot	lin.ft.
link (surveying)	spell out
liquid	spell out
liter	l.
logarithm	log (no period)
logarithm, natural	log,
longitude	long.

Louisiana	La.
low-pressure	l-p.
lumen	spell out
magnetomotive force	m.m.f.
Maine	Me.
Manitoba	Man.
manufacturing	mfg.
March	spell out
Maryland	Md.
mass	spell out
Massachusetts	Mass.
mathematics	spell out
maximum	max.
May	spell out
mean effective pressure	m.e.p.
mean horizontal candle power	spell out
megawatt	spell out
megohm	spell out
melting point	spell out
meter	m.
meter-kilogram	m-kg.
Michigan	Mich.
microampere	spell out
microfarad	m.f.d.
micron	spell out
microwatt	spell out
mile	spell out
miles per hour	m.p.h.
miles per hour per second	miles per hr. per sec.
milliampere	spell out
millifarad	spell out
milligram	mg.
millihenry	spell out
millilambert	spell out
milliliter	ml.
millimeter	mm.
millimicron	spell out
million	spell out
million gallons per day	m.g.d.
millivolt	mv.

minimum	min.
Minnesota	Minn.
minute	min.
Mississippi	Miss.
Missouri	Mo.
molecular weight	spell out
mol	spell out
Montana	Mont.
month	spell out
morning	a.m.
motor-generator	spell out
Nebraska	Neb.
Nevada	Nev.
New Hampshire	N.H.
New Jersey	N.J.
New Mexico	N.M.
New York	N.Y.
North Carolina	N.C.
North Dakota	N.D.
November	Nov.
number	no.
numbers	nos.
October	Oct.
Ohio	spell out
ohm	spell out
ohm-centimeter	ohm-cm.
Oklahoma	Okla.
Oregon	Ore.
ounce	oz.
ounce-foot	oz-ft.
ounce-inch	oz-in.
page	p.
pages	pp.
parts per million	p.p.m.
Pennsylvania	Pa.
percentum	per cent
pint	pt.
potential	spell out
potential difference	p.d.
pound	lb.

pound-foot	lb-ft.
pound-inch	lb-in.
pounds per brake horsepower-hour	lb. per b.hp-hr.
pounds per square foot	lb. per sq.ft.
pounds per square inch	lb. per sq.in.
power factor	p.f.
quart	qt.
radian	spell out
railroad	R.R.
railway	Ry.
reactive kilovolt ampere	spell out
reactive volt ampere	spell out
Réaumur	R.
revolutions per minute	r.p.m.
revolutions per second	r.p.s.
Rhode Island	R.I.
rod (land measure)	spell out
round	rd.
secant	sec
second	sec.
second-feet	sec-ft.
section	Sec.
September	Sept.
shaft horsepower	shaft hp.
sine	sin
South Carolina	S.C.
South Dakota	S.D.
specific gravity	sp.gr.
specific heat	sp.ht.
spherical candle power	spell out
square centimeter	sq.cm.
square foot	sq.ft.
square inch	sq in.
square kilometer	sq.km.
square mile	sq. mile
square millimeter	sq.mm.
square yard	sq.yd.
standard	std.
stere	spell out
tangent	tan

temperature	spell out
Tennessee	Tenn.
tensile strength	spell out
Texas	Tex.
thousand	M
ton	spell out
ton-mile	spell out
Utah	spell out
Vermont	Vt.
versed sine	versin
Virginia	Va.
volts	spell out
volt-ampere	spell out
volt-coulomb	spell out
volume	vol.
Washington	Wash.
watt	spell out
watt hour	spell out
watts per candle	spell out
weight	wt.
West Virginia	W. Va.
Wisconsin	Wis.
Wyoming	Wyo.
yard	yd.
year	yr.

APPENDIX C

OUTLINE OF A COURSE ON THE PREPARATION OF ENGINEERING REPORTS

The following is an outline of assignments that may be followed in conducting a three quarter-credit course on the preparation of engineering reports, which affords about thirty contacts. The problems assigned are on some phase of engineering and the written work submitted by the students is criticized from the standpoint both of the quality of the English and of the technical accuracy of the engineering features of the presentation. If such a course is taught by a member of the engineering staff, it usually adds to the value of the course if a member of the English staff cooperates in the criticism of the papers.

Class

Period

Employment of the Class Period

1. Organize the class. Outline the objectives of the course. Assign Chapter I, and the study and classification of certain reports on file in the library.
2. Discuss Chapter I. Supplement with illustrations from practice. Assign Chapter II.
3. Discuss Chapter II. Supplement with illustrations. Criticize papers submitted on assignment of period 1, especially English, typography, and content. Assign writing of a letter report on a subject to be selected from a list furnished by instructor. Study Chapter III.

Class

Period

Employment of the Class Period

4. Discuss Chapter III and illustrate elements of reports by good examples. Assign preparation of a title page and letter of transmittal.
5. Criticize the material submitted on assignment of period 3. Review and illustrate material in Chapter III. Assign writing of a foreword or preface and a table of contents for a report from which these elements have been deleted.
6. Criticize the material submitted on assignment of period 4. Discuss functions of letters of transmittal, acknowledgments, foreword, etc. Assign Chapter IV.
7. Criticize the material submitted on assignment of period 5. Discuss Chapter IV. Assign the writing of a statement of a problem and appropriate description of the method of attack for a report on an assigned subject.
8. Discuss the problems involved in analyzing data and reaching correct conclusions. Assign the writing of appropriate conclusions from data furnished by instructor, also Chapter V (pages 66 to 76).
9. Criticize the material submitted on the assignment of period 7. Discuss first half of Chapter V. Assign a subject for an interview with public officials, other professors, or practicing engineers, also last half of Chapter V.
10. Criticize the material submitted on the assignment of period 8. Discuss last half of Chapter V. Assign preparation of a questionnaire.
11. Criticize the material submitted on the assignment of period 9. Discuss bibliographies. Assign preparation of a bibliography, preliminary copy to be ready at next period.
12. Conference with each student on his preliminary bibliography and assign completion of bibliography. Usually at this time it is desirable to discuss other work the student has submitted.
13. Criticize the material submitted on assignment of period 10. Discuss securing information by field examination. Assign Chapter VI (pages 85 to 93).
14. Criticize the material submitted on assignment of period 11. Discuss Chapter VI (pages 85 to 96). Assign preparation

Class**Period****Employment of the Class Period**

- of an outline for a report available in library and balance of Chapter VI.
15. Discuss last half of Chapter VI, especially mechanics of arrangement of report material. Assign Chapter VII.
 16. Discuss Chapter VII. Criticize the material submitted on assignment of period 14. Assign a problem involving the tabulation of data in the most effective manner.
 17. Continue discussion of Chapter VII, especially graphs and curves. Assign preparation of a graph or curve sheet to illustrate material furnished to the student.
 18. Criticize the material submitted on assignment of period 16. Discuss bar diagrams and pictorial charts. Assign preparation of a bar diagram to illustrate a tabulation to which the student is referred.
 19. Criticize the material submitted on assignment of period 17. Discuss use of photographs, photostats, flow sheets, and organization diagrams. Assign preparation of an organization diagram and Chapter VIII.
 20. Criticize the material submitted on assignment of period 18. Discuss Chapter VIII. Assign the preparation of a report form for a specified set of conditions.
 21. Criticize the material submitted on assignment of period 19. Discuss the final report which is to be a formal report on a selected subject. Assign the statement of the problem for each student's final report.
 22. Criticize the material submitted on assignment of period 20. Review the subject of collection of data for reports with especial reference to the final problem. Assign the preparation of the bibliography for the final report.
 23. Criticize the material submitted on assignment of period 21. Discuss the collection of field data for the final report. Assign the collection of field data for the final report.
 24. Conferences with individual students on their bibliographies. Check progress on collection of data for the final report.
 25. Conference with individual students. Check progress on collection of data for final report.

Class**Period****Employment of the Class Period**

26. Review the subject of outlines with special reference to the final report. Assign preparation of outline for final report.
 27. Review the subject of presentation of data with special reference to the final report.
 28. Criticize outlines for the final report. Assign preparation of the final report.
 29. Conference with individual students on the final report.
 30. Summarize the suggestions and criticisms that have grown out of the conferences with individual students as their final report has taken form.
- Final reports to be filed on or before the final examination period assigned to the course.

APPENDIX D

LIST OF BOOKS AND REPORTS FOR REFERENCE

The following books and reports have been found useful for illustrative purposes in connection with the presentation of the various factors involved in the preparation of engineering reports. Many types of reports are included in the list and the examples are of various degrees of excellence.

Books

1. American Society of Mechanical Engineers, "Style Manual for Engineering Authors and Editors," The American Society of Mechanical Engineers, 29 West 39th Street, New York, 1927.
2. AYDELOTTE, FRANK, "English and Engineering," 2d ed., McGraw-Hill Book Company, Inc., New York, 1923.
3. BAKER, RAY PALMER, "The Preparation of Reports," Ronald Press Company, New York, 1924.
4. GUAM, CARL G., and HAROLD F. GRAVES, "Report Writing," Prentice-Hall, Inc., New York, 1929.
5. HALL, S. R., "The Handbook of Business Correspondence," McGraw-Hill Book Company, Inc., New York, 1923.
6. HARBARGER, S. A., "English for Engineers," 3d ed., McGraw-Hill Book Company, Inc., New York, 1934.
7. MARSHALL, W. C., "Graphical Methods," McGraw-Hill Book Company, Inc., New York, 1921.
8. MEAD, D. W., "Contracts, Specifications and Engineering Relations," 2d ed., McGraw-Hill Book Company, Inc., New York, 1920.

9. PARK, C. W., "English Applied in Technical Writing," F. S. Crofts & Co., 1926.
10. RIGGLEMAN, J. R., "Graphic Methods for Presenting Business Statistics," McGraw-Hill Book Company, Inc., New York, 1926.
11. SAUNDERS, ALTA GWINN, and CHESTER REED ANDERSON, "Business Reports," McGraw-Hill Book Company, Inc., New York, 1929.
12. WATT, H. A., and P. B. McDONALD, "Composition of Technical Papers," McGraw-Hill Book Company, Inc., New York, 1925.

Reports

1. "Thirteenth annual report of the Board of Water Supply of the City of New York," accompanied by report of the chief engineer, Jan. 1, 1919.
2. "Fabrication of welded piping design," The Linde Air Products Company, New York, 1929.
3. "Design and control of concrete mixtures," Portland Cement Association, January, 1927.
4. "Investigation of the effect of truck impact on concrete pavement," Report 31-7, Department of Public Works and Buildings, Division of Highways, Bureau of Materials, Springfield, Ill., Dec. 31, 1931.
5. "The development and utilization of the power of the St. Lawrence River in the international section," Sanderson and Porter, appendix K, p. 627, The St. Lawrence Navigation and Power Project, H. G. Moulton, C. S. Morgan, A. L. Lee, The Brookings Institute, Washington, D. C., 1929.
6. "Report on valuations of the properties as of June, 1930, of New York Rapid Transit Corp., Williamsburg Power Plant Corp., Interborough Rapid Transit Co., and Manhattan Railway Co.," Transit Commission, State of New York, Bureau of Unification and Transit Readjustment, June, 1931.
7. "Recommendations and general plans for a comprehensive passenger subway system for the City of Chicago," B. J. Arnold, Committee on Local Transportation, January, 1911.

8. "Report of the probable gross earnings and division of profits between the Chicago street railway companies and the City of Chicago," B. J. Arnold, Nov. 8, 1905. (*Arnold Report 6.*)
9. "Report giving specifications for reconstruction and extension of the properties of the Chicago street railway companies," B. J. Arnold, Nov. 21, 1905. (*Arnold Report 7.*)
10. "Report to Hon. John C. Lodge, mayor, on financing a subway plan," Detroit, Board of Street Railway Commissioners and Rapid Transit Commission, July 2, 1929.
11. "Proposed financial plan for a rapid transit system for the city of Detroit," Rapid Transit Commission, Detroit, 1923.
12. "Studies in securities," Vols. 1-4, J. H. Oliphant & Company, 1927-1930.
13. "Report and recommendations of special counsel to the Transit Commission on the proposed plan of readjustment directed by the legislature," Transit Commission, Metropolitan Division of the Department of Public Service of the State of New York.
14. "Annual Report," Transit Commission, Metropolitan Division of the Department of Public Service, New York City, 1932.
15. "Valuation of City of Ames, Iowa, electric utility property," Anson Marston and T. R. Agg, December, 1932.
16. "A report to the City of Freeport and the Freeport Water Company on the value of the present property of the Freeport Water Company, its enlargement and adequate rates," Anson Marston, F. E. Turneure, and J. W. Alvord, April 15, 1912.
17. "Valuation of the Amana Society industrial property, Amana, Iowa," Anson Marston, April, 1932.
18. "Control of floods in the alluvial valley of the lower Mississippi River," Vol. 1, Chief of Engineers, U. S. Army, 1931.
19. "Comparative tests of clay, sand-lime, and concrete brick masonry," A. H. Beyer and W. J. Krefeld, *Bulletin 12*, Testing Laboratories, Department of Civil Engineering, Columbia University, New York, April, 1923.

20. "Strength of flat-arch floor construction," Part I, "end spans," G. E. Large and C. T. Morris, *Bulletin* 78, Engineering Experiment Station, Ohio State University, July, 1933.
21. Letter reports by D. B. Steiman, Gustav Lindenthal, and J. E. Greiner, on practicability of a certain type of bridge, Appendix A, "The Wichert Truss," D. B. Steiman, D. Van Nostrand Company, Inc., New York, 1932.
22. "The Book of Iowa, Iowa's Industrial Survey," State of Iowa, 1932.
23. "Report of the Hoover-Young San Francisco Bay Bridge Commission," California State Printing Office, Sacramento, 1930.
24. "Editor's reference book on cement and concrete," Portland Cement Association, 1925.
25. "Report of the director of research," Portland Cement Association, November, 1928.
26. "Some test data on fireproof floor construction. Relating to cinder, concrete, terra cotta and gypsum," Clinton Wire Cloth Co., Clinton, Mass., 1913.
27. "Lessons of the storm," Jones & Laughlin Steel Corp., Pittsburgh, Penn., November, 1926.
28. United Engineering Trustees, Inc., New York, reports for 1929-1930.
29. "Report of a survey of transportation on the state highways of Pennsylvania," The Bureau of Public Roads, U. S. Department of Agriculture and the Department of Highways, Commonwealth of Pennsylvania, 1928.
30. "Dams and control works constructed by the Bureau of Reclamation, U. S. Department of the Interior," Government Printing Office, Washington, D. C., 1929.
31. "Investigation of pollution of the Des Moines River from Estherville to Farmington," A. H. Weiters, State Department of Health, Des Moines, Iowa, 1934.
32. "Loading tests on a new composite type short span highway bridge," R. H. Baldock and C. B. McCullough, *Technical Bulletin* 1, Oregon Highway Department, Oregon State Highway Commission, 1932.
33. "Carrying out the master plan," report to the common council of the City of Detroit, Oct. 2, 1925.

34. "Vehicular traffic in 1928, City of Detroit," Rapid Transit Commission, Detroit, 1929.
35. "Report of sub-committee of committee on scholarship on student ability," Stanford University, 1923.
36. "Report upon the comparative shock resistance of standard V thread and nut connections and Dardelet thread and nut connections," Testing Laboratories, Department of Civil Engineering, Columbia University, New York, 1929.
37. "Annual report of the State Board of Engineering Examiners," State of Iowa, Des Moines, Iowa, 1928.
38. "State higher educational institutions of Iowa," report to the Iowa State Board of Education, *Bulletin* 19, Government Printing Office, Washington, D. C., 1916.
39. "Iowa River, Iowa and Minnesota," report from the Chief of Engineers on Iowa River, Iowa and Minnesota, covering navigation, flood control, power development, and irrigation, Government Printing Office, Washington, D. C., 1930.
40. "Twenty year development program," Part III, proposed for the Division of Engineering, Iowa State College, Ames, Iowa, January, 1933.
41. "Treated lumber, its uses and economies," report of sub-committee of the National Committee on Wood Utilization, P. A. Hayward, Government Printing Office, Washington, D. C., 1930. (Fifteenth report of a series.)
42. "Seasoning, handling and care of lumber," manufacturers subcommittee of the National Committee on Wood Utilization, A. B. Cone, Government Printing Office, Washington, D. C., 1929. (Ninth report of a series.)
43. "Annual report of the State Board of Engineering Examiners, 1931," State of Iowa, Des Moines, Iowa.
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46. "Analysis of rigid frame concrete bridges," Portland Cement Association, September, 1933.
47. "Operating cost of the individual farm electric plant," F. D. Paine and F. J. Zink, Project 123, *Report* 7. Iowa

- Engineering Experiment Station, Iowa State College, Ames, Iowa, June, 1932.
48. "Silting of reservoirs," T. U. Taylor, *Bulletin* 3025, University of Texas, July 1, 1930.
 49. "Transportation, survey of current methods of study, instruction, research, and experimentation," V. Topping and S. J. Dempsey, Committee on Transportation, Yale University, 1926.
 50. "A comparative study of engineering education in the United States and in Europe," W. E. Wickenden, *Bulletin* 16, Society for Promotion of Engineering Education, 1930.
 51. "An investigation of the constitution of portland cement and properties of cement components with relations to disintegration of concrete," R. J. Colony and D. L. Snader, Testing Laboratories, Department of Civil Engineering, Columbia University, New York, July, 1931.
 52. "Report of the national screw thread commission," Bureau of Standards, U. S. Department of Commerce, Washington, D. C., revised 1933.
 53. "Some interpretations and conclusions of the land-grant radio survey," T. F. Tyler, Secretary and Research Director, National Committee on Education by Radio, Washington, D. C., 1933.
 54. "Progress in hydraulic engineering," hydroelectric conference, Philadelphia, 1932. (Reprint from *Engineers and Engineering*.)
 55. "Ways and means to traffic safety," recommendations of national conference on street and highway safety, Washington, D. C., 1930.
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- F. L. Olmsted, J. C. Nichols, national conference on city planning, 1928.
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 61. "Eighth study of motor vehicle accidents in the State of Connecticut," Yale University Press, 1932.
 62. "Annual report of the public works department," City of Boston, 1932.
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 67. "Earthquake-resistant structures," W. M. Butts, A.I.S.C. New York, 1928.
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73. "Mid-Hudson Bridge, State of New York, Department of Public Works," preliminary report to Superintendent of Public Works, Albany, N. Y., Jan. 9, 1924.
74. "Report of a plan of highway improvement in the regional area of Cleveland, Ohio," Bureau of Public Roads, U. S. Department of Agriculture, 1928.
75. "Report of the commission to study the proposed highway to Alaska," H. E. Rice, E. W. Sayer, and Malcolm Elliott, Government Printing Office, Washington, D. C., 1933.
76. "Seventh annual report of the commissioner of main roads for the year ended June 30, 1928," (Queensland), 1928.
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80. "Report on Higher education in the State of New York for the school year ending July 31, 1931," Commissioner of Education, State of New York, *Bulletin* 1020, University of the State of New York, Albany, N. Y., 1933.
81. "Tentative plan of Transit Commission for readjustment and unification of rapid transit railroads and related power properties in the City of New York," December, 1931. (Memorandum.)
82. "Tentative plan and readjustment agreement for the readjustment and unification of rapid transit railroads and related power properties in the City of New York," Transit Commission, New York, Dec. 19, 1931.
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85. "Annual report," The Port of New York Authority, 1930.
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90. "The technical bases for the recommendations of the Board of Review," Part II, report of the Engineering Board of Review of the Sanitary District of Chicago on the lake lowering controversy and a program of remedial measures, 1925.
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96. "A study of technical institutions" (summary report), Society for the Promotion of Engineering Education, June, 1931.
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98. "Tentative report of the committee on construction," Division of Building and Housing, Bureau of Standards, Washington, D. C., Dec. 3, 1931.
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